

Coastal Inlets Research Program

advancing inlet science and engineering



HQ Technical Monitor:
ERDC Technical Director:
CIRP Program Manager:

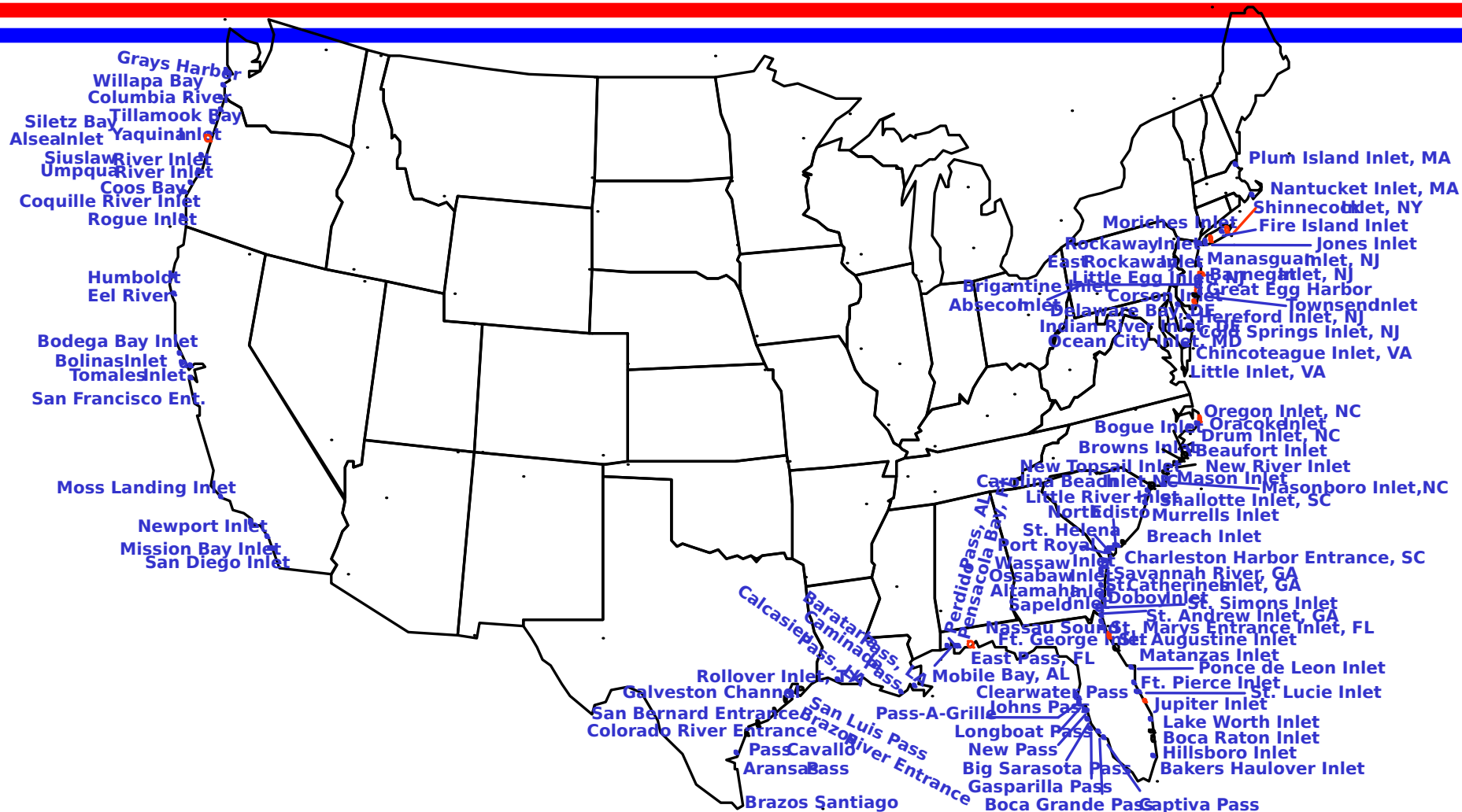
Barry Holliday
Jim Clausner
Nick Kraus

O&M Funded Program
Conducted at ERDC, Coastal & Hydraulics Laboratory, Vicksburg, MS

Federal Coastal Inlets

~ 150 major inlets

~ 500 total inlet & harbor channels



Coastal Inlet Navigation Channel O&M



The Corps moves
250-350 Million cu yd of sediment annually

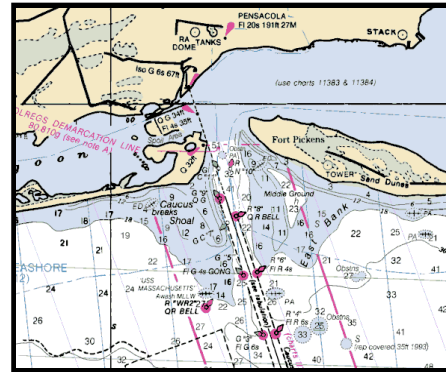


**Costing > \$800~ 900 Million per
year**

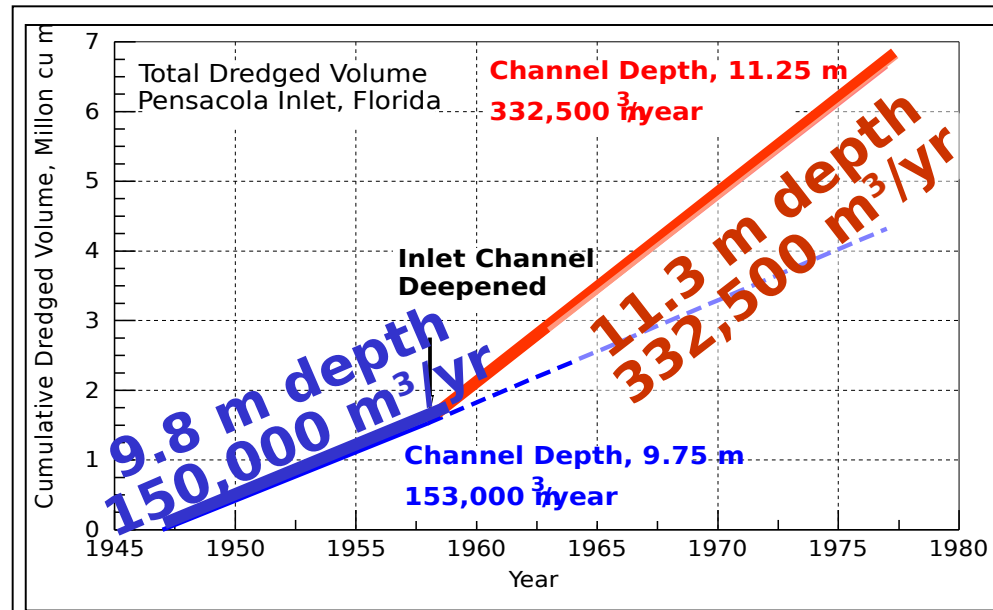
CIRP Objectives



- **Conduct R&D to reduce O&M costs at inlet navigation projects.**
 - **Treat inlet channels & adjacent beaches as a system.**
 - **Transfer technology.**
 - Guidance documents,
Workshops
 - Engineering models, Web site,
Advanced models, PC software
- Deepening a channel can greatly increase dredging requirements; need to predict this.* →



Pensacola Pass, FL



CIRP– Developing predictive technology and engineering guidance to address:



- **Advance maintenance dredging**
- **Channel widening, deepening**
- **Jetty modification**
- **Channel reliability**
- **Scour reduction**
- **Bypassing to adjacent beaches**
- **Ebb & flood shoal mining**
- **Efficiency of engineering studies**



**Packery Channel, TX,
under Federal construction
2005-2006,
based in part on CIRP technology**

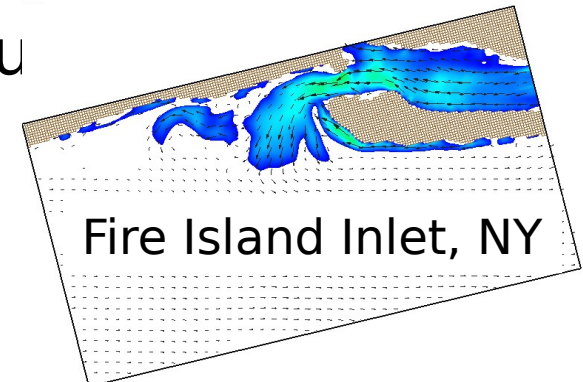
CIRP - Vision

CIRP....advancing inlet science and engineering

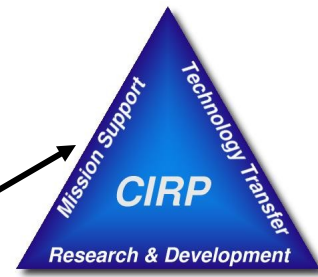


- District engineers and scientists run CIRP desk-top models
 - Reconnaissance-, feasibility-, and design-level O&M projects
 - Inlet channels, shoals, structures, and adjacent beaches
 - Short-term (storm cycles) to long-term (project life) analyses
- Web-based databases, tools, and downloads
 - Rapid access to integrated knowledge and guidance

• Predictive technology for inlets, structures, and beaches



CIRP- Seven work units



Program Management & Tech Transfer

Validation of Technology at Coastal Inlets

Bypassing & Channels

Geomorphology

Structure Asset Mgt

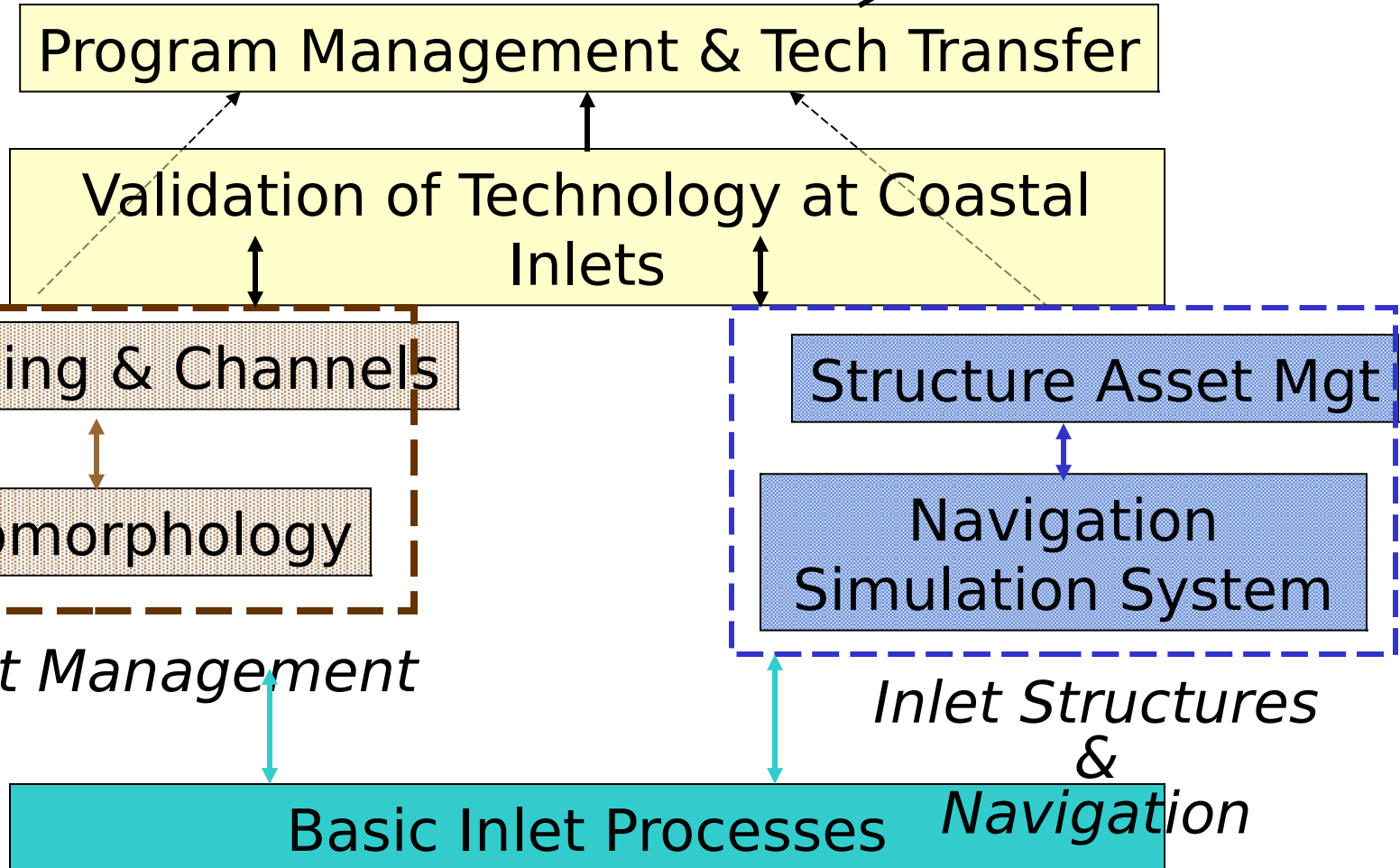
Navigation Simulation System

Inlet Structures &

Navigation

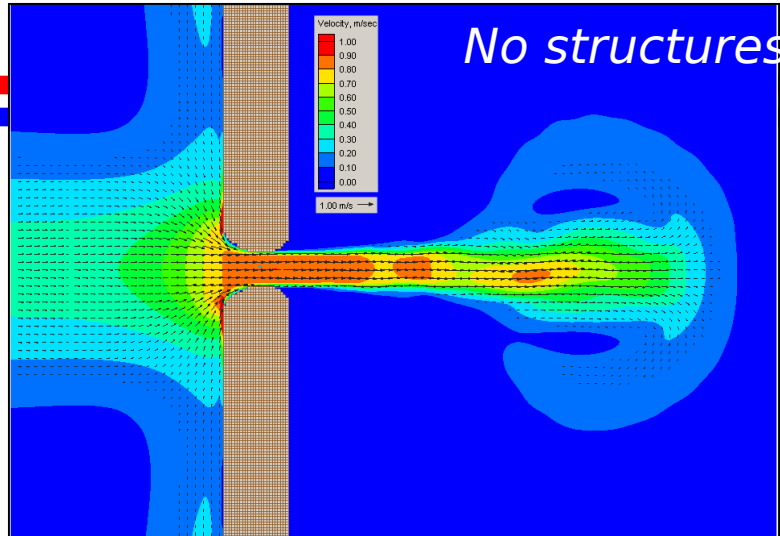
Basic Inlet Processes

Sediment Management



WU 1. Basic Inlet Processes

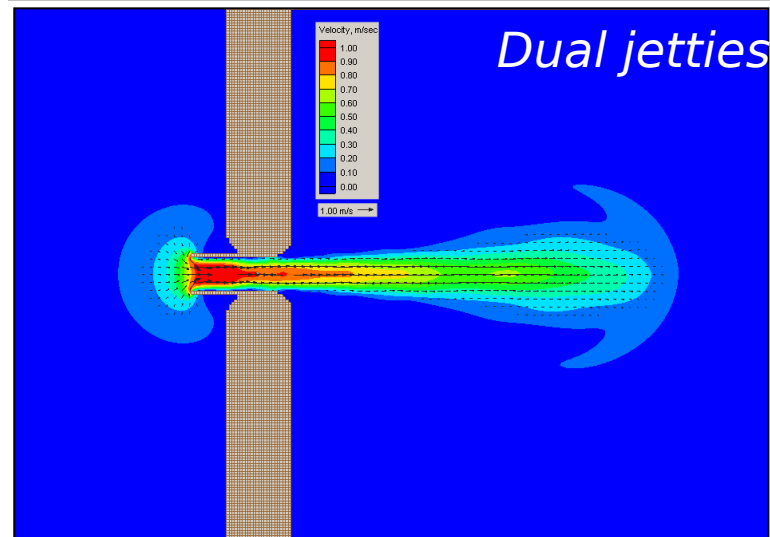
Lihwa Lin



Need: Improve processes integral to modeling waves, currents, and sediment transport at inlets.

Approach: Individually evaluate and improve modeling components –

- Wave diffraction.
- Wave breaking over shoals.
- Sediment transport at inlets.



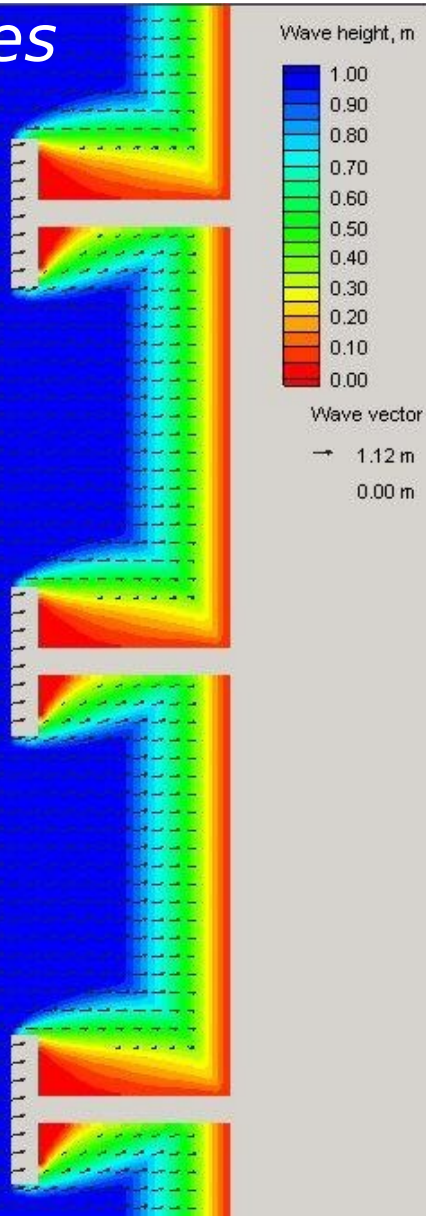
Evaluating Tidal Flow for
Unstructured and Jettied Inlets

WU 1. Basic Inlet Processes

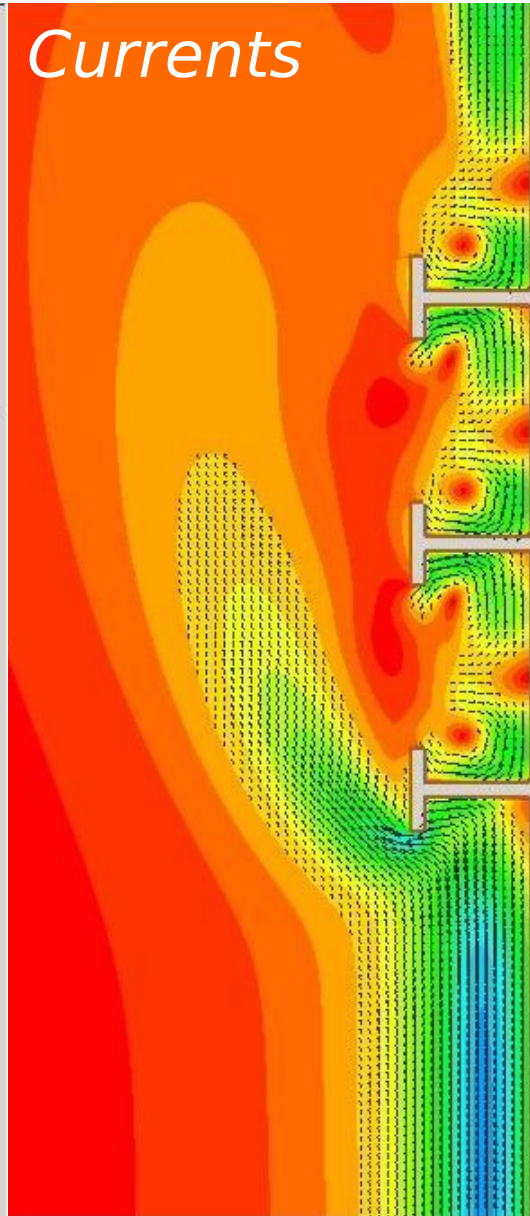
Coupling Circulation and Wave Models



Waves

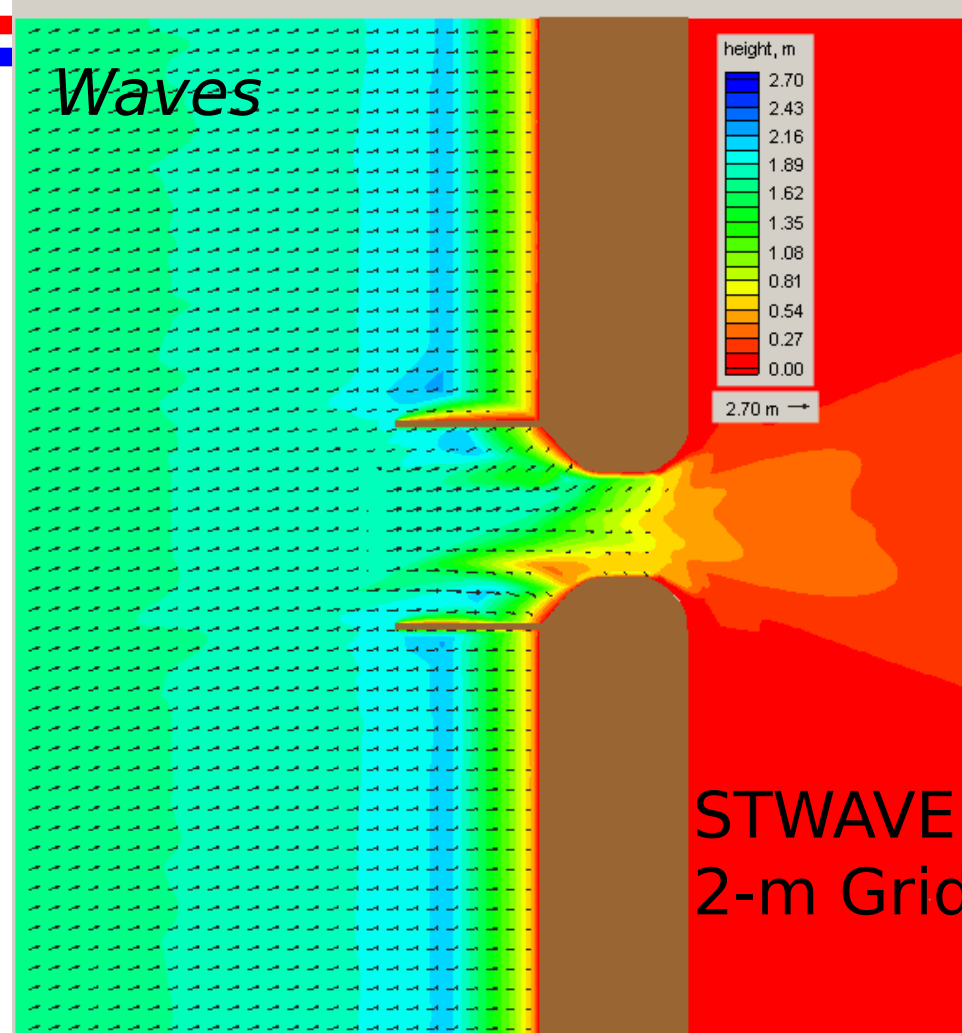
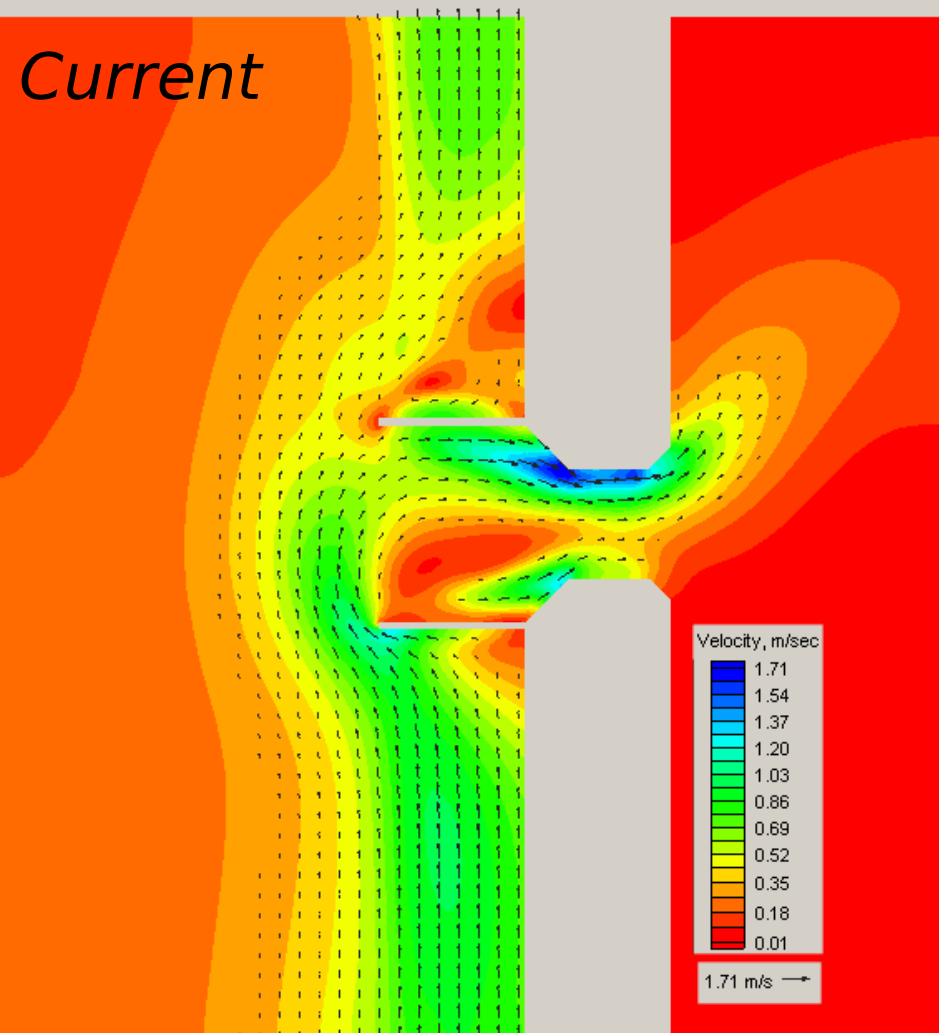


Currents



WU 1. Basic Inlet Processes

Waves and Current for Jettied Inlet



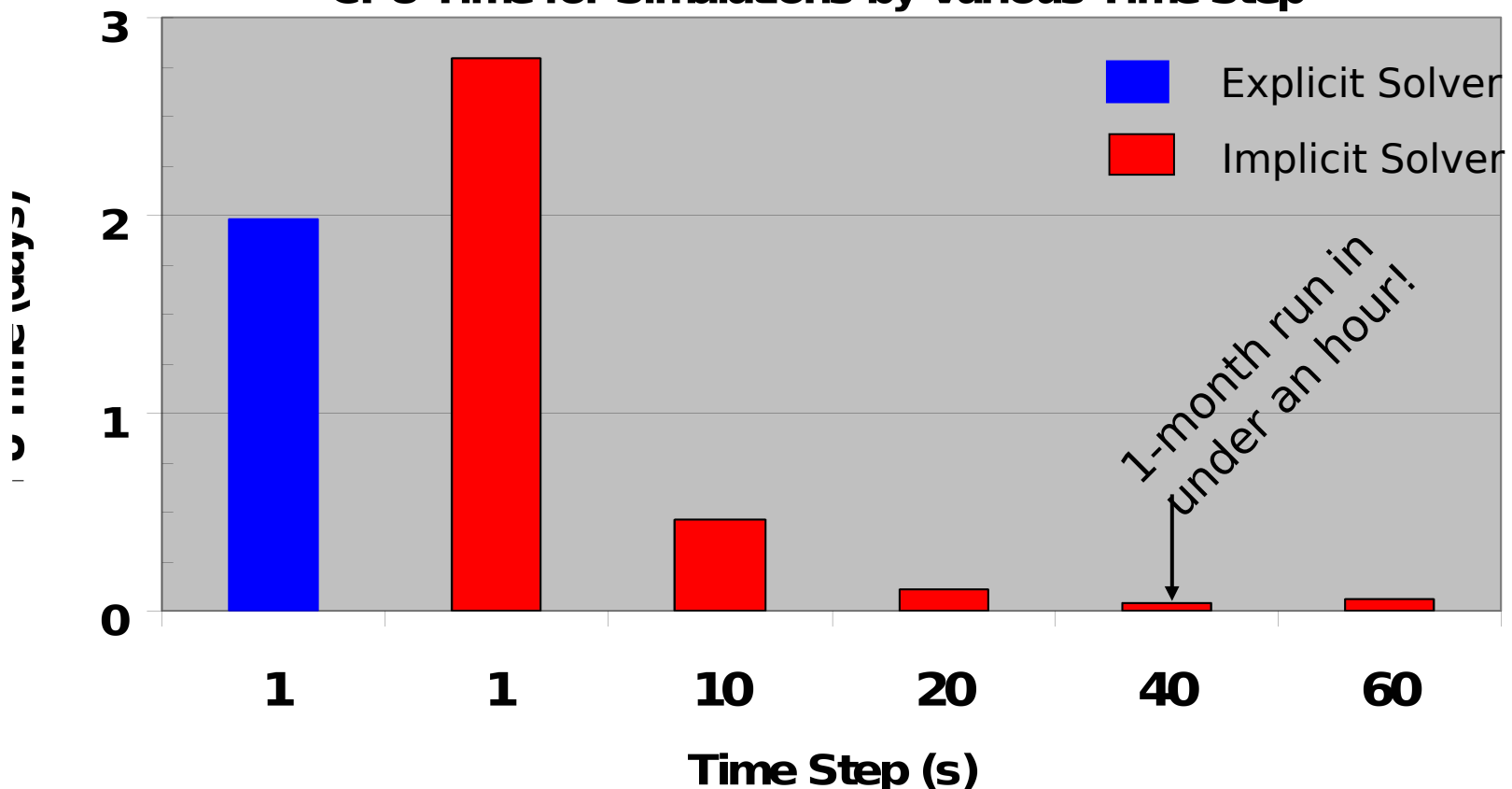
WU 1. Basic Inlet Processes

CPU Time for Simulations by M2D Implicit Solver



Simulation Period = 1 month (30 days)

CPU Time for Simulations by Various Time Step



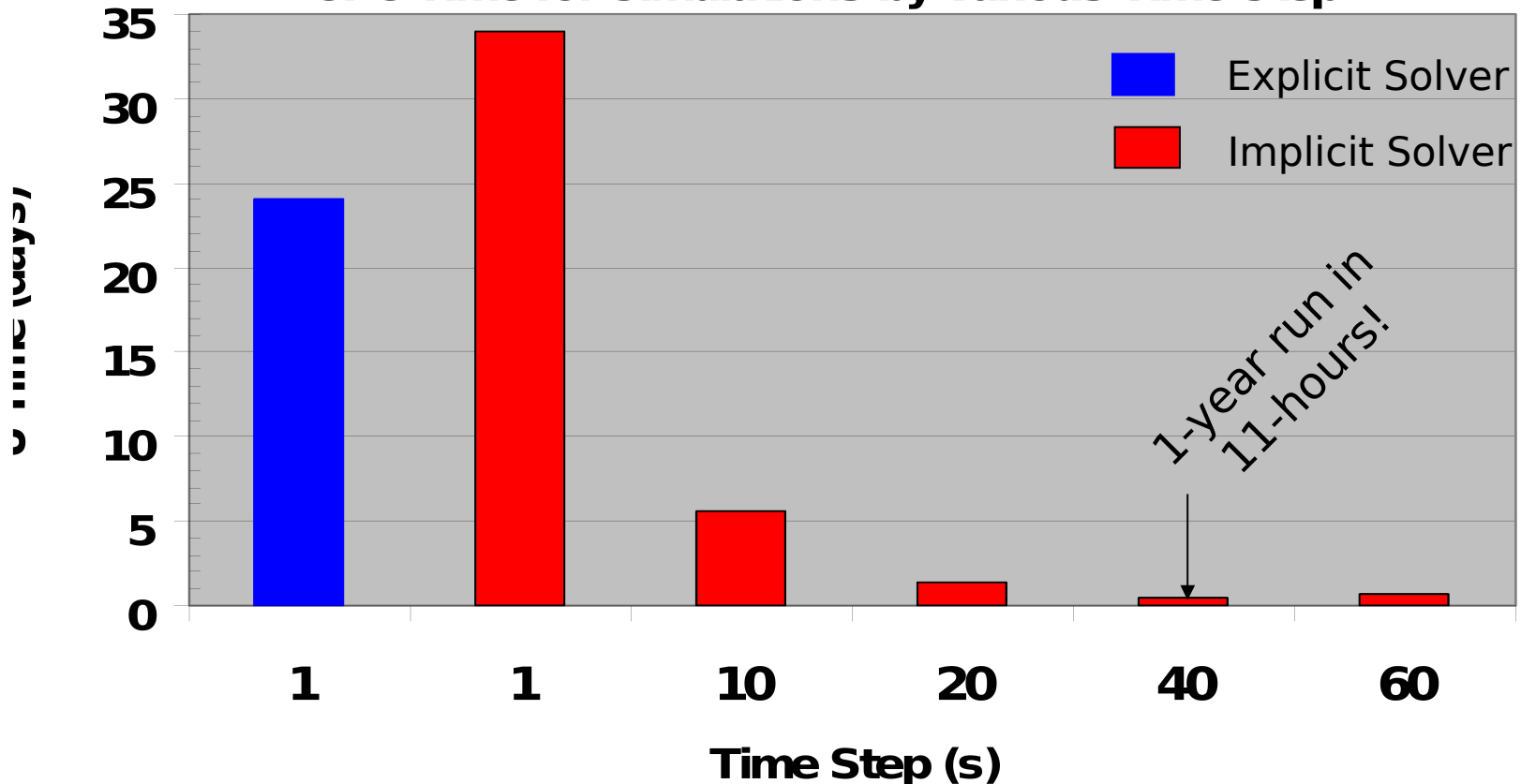
WU 1. Basic Inlet Processes

CPU Time for Simulations by M2D Implicit Solver



Simulation Period = 1 year

CPU Time for Simulations by Various Time Step



WU 1. Basic Inlet Processes

Products



Boynton Beach, F

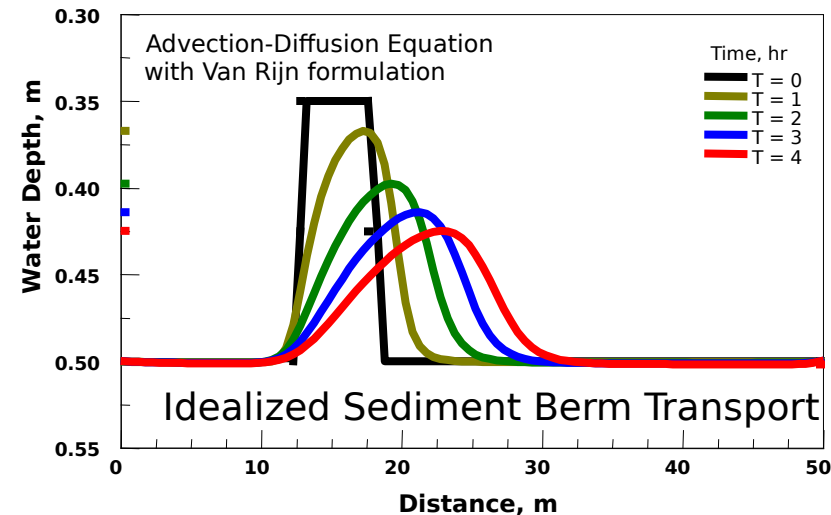
Improved wave and hydrodynamic models to simulate:

- Jetties and structures with arbitrary configurations
- Choice of sediment transport relationships, including multiple grain sizes
- Critical wave breaking processes for sediment transport (undertow)



WU 2. Inlet Bypassing & Nearshore Berms

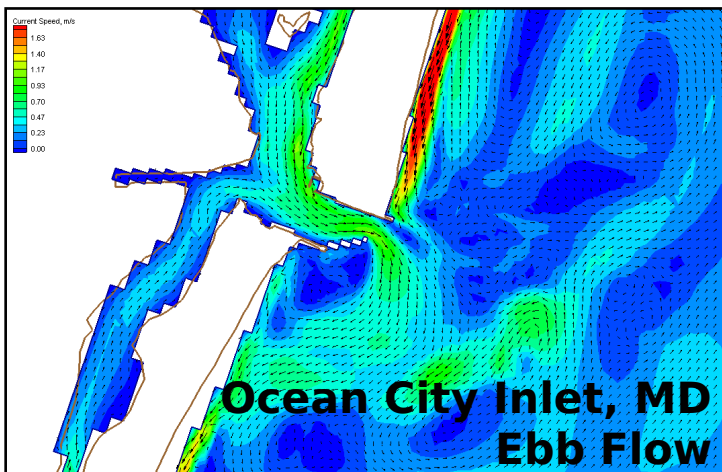
Mary Cialone



Need: Predictive technology to treat inlet channels & adjacent beaches as a sand-sharing system.

Approach: Develop **Inlet Modeling System (IMS)** to address:

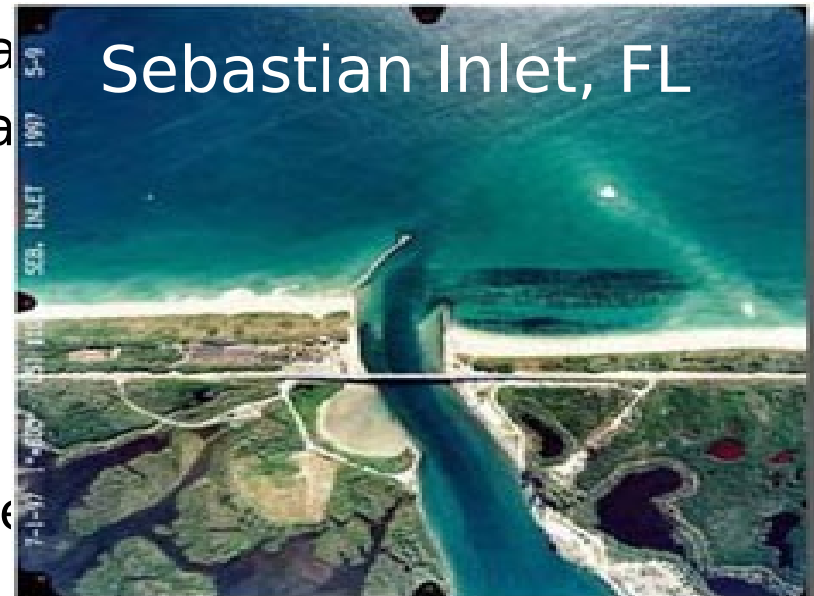
- Channel infilling & design.
- Bypassing.
- Nearshore berm performance as a disposal option.
- Navigation reliability.
- Integrated inlet processes.



IMS-M2D Capabilities

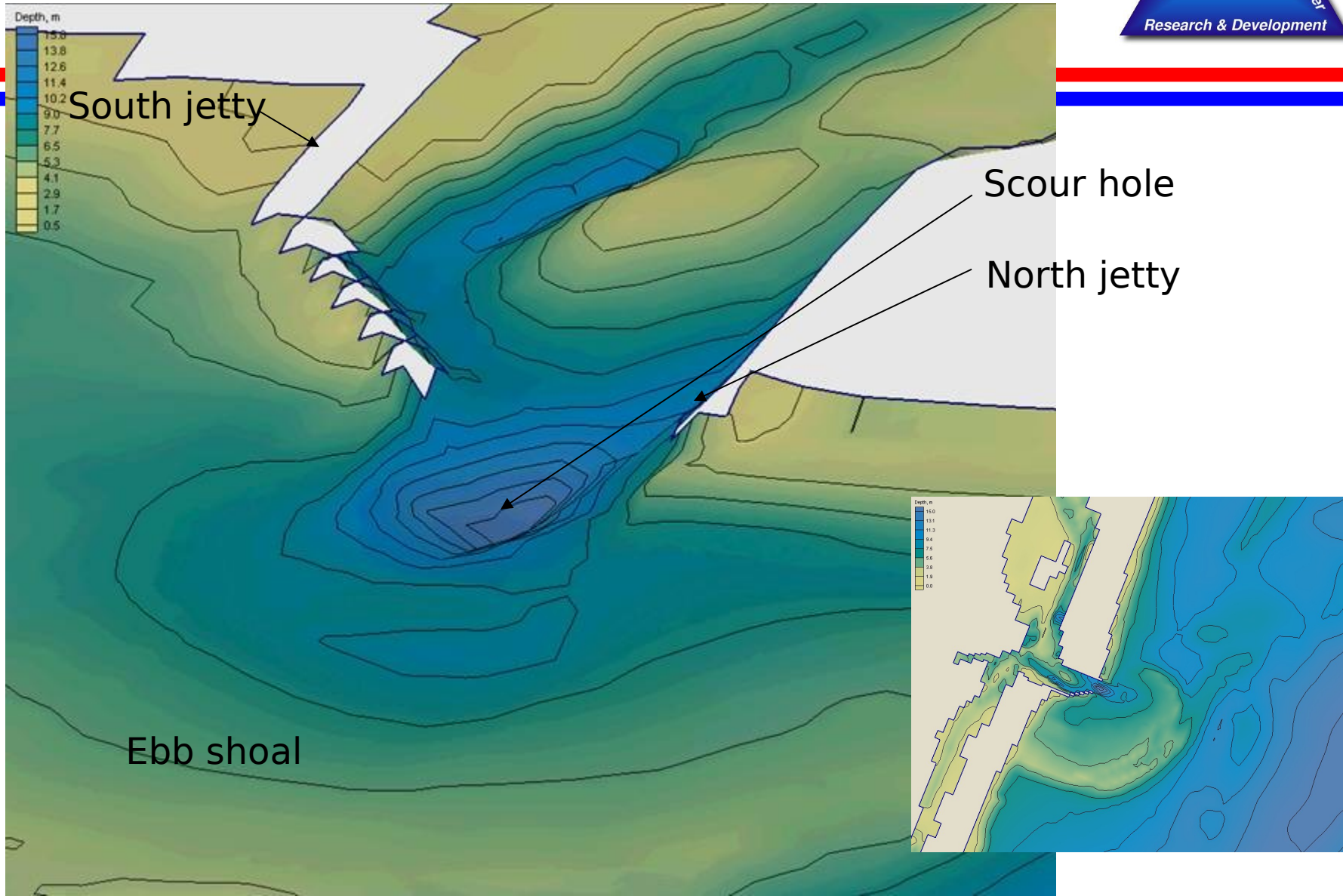


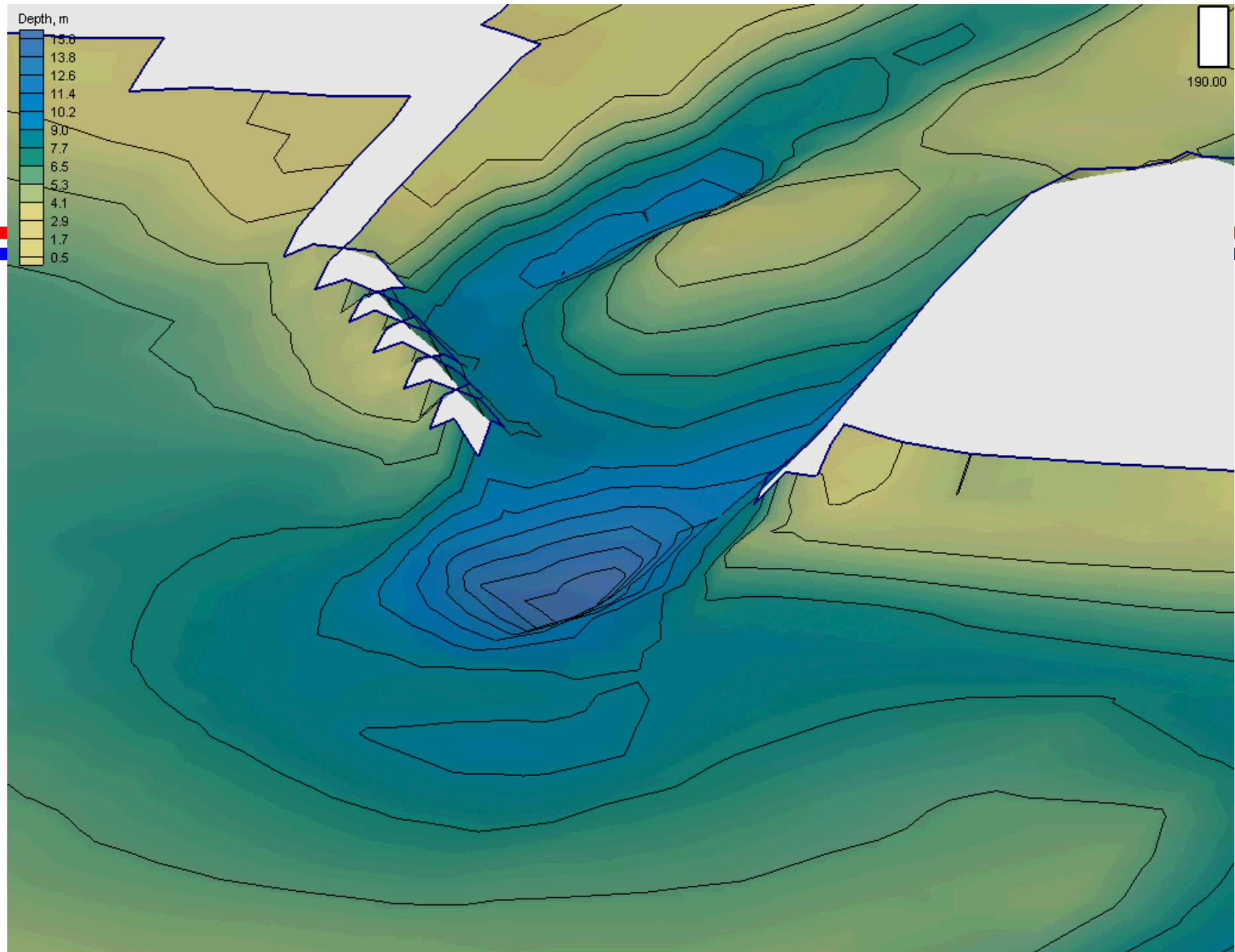
- Horizontal circulation model
 - Predicts water level, current, sediment transport, morphology change
- Rectilinear grid, variable cell size
- Multiple types of forcing:
 - Water level, wind, waves, flow rate
- Efficient calculations, memory storage
- Easy to configure & run
- Convenient for small projects
- Hard bottom
- Flooding/drying
- Explicit and implicit solution schemes



Ocean City, MD

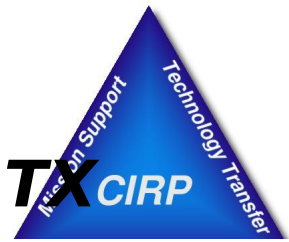
Morphology Change Dec 1992 Northeast



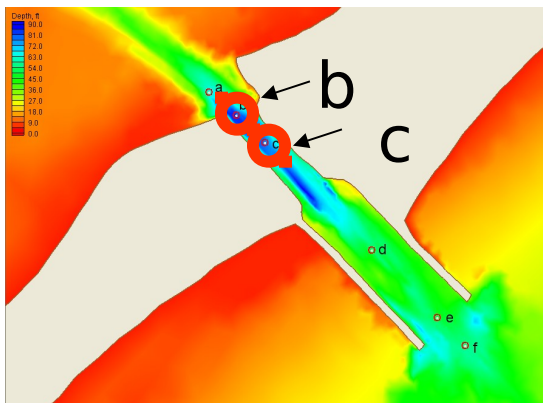
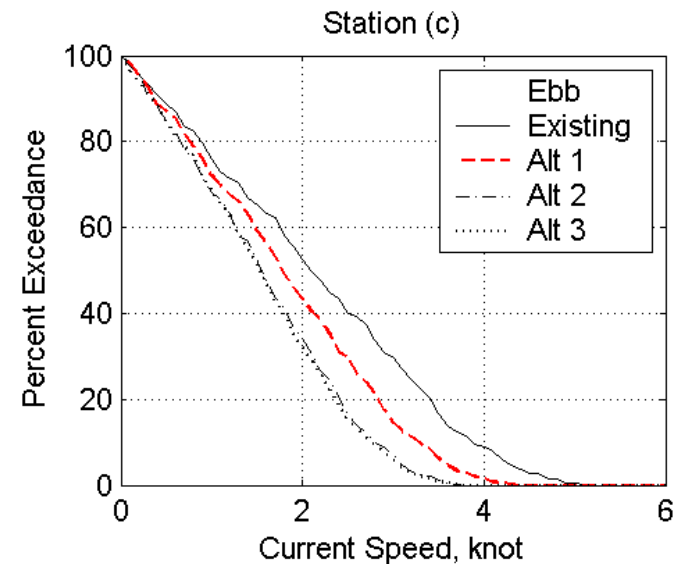
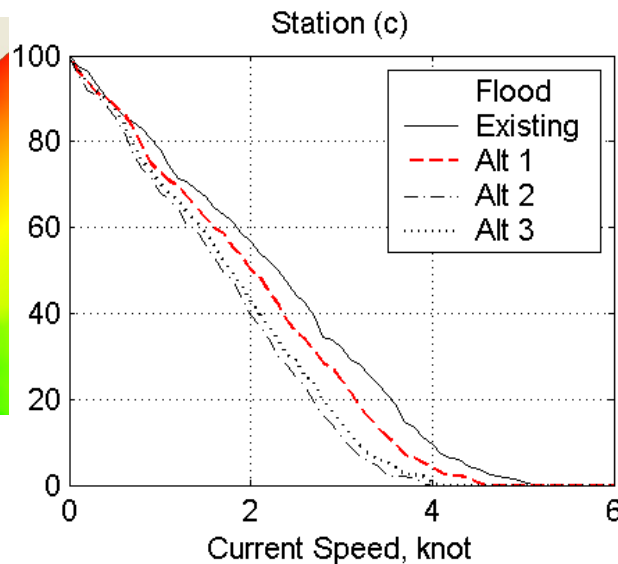
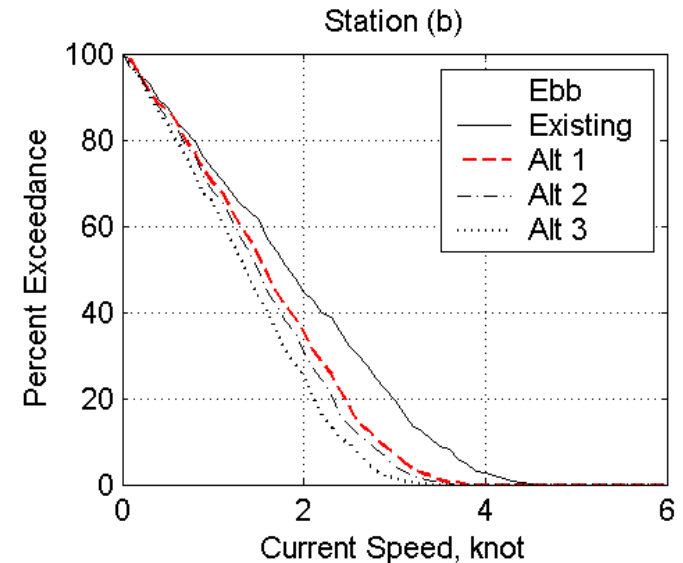
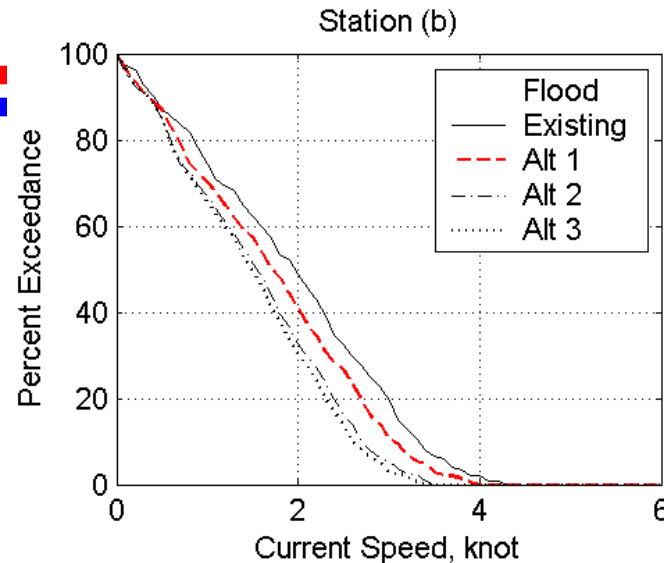


WU 1. Basic Inlet Processes

Application to Matagorda Ship Channel, TX



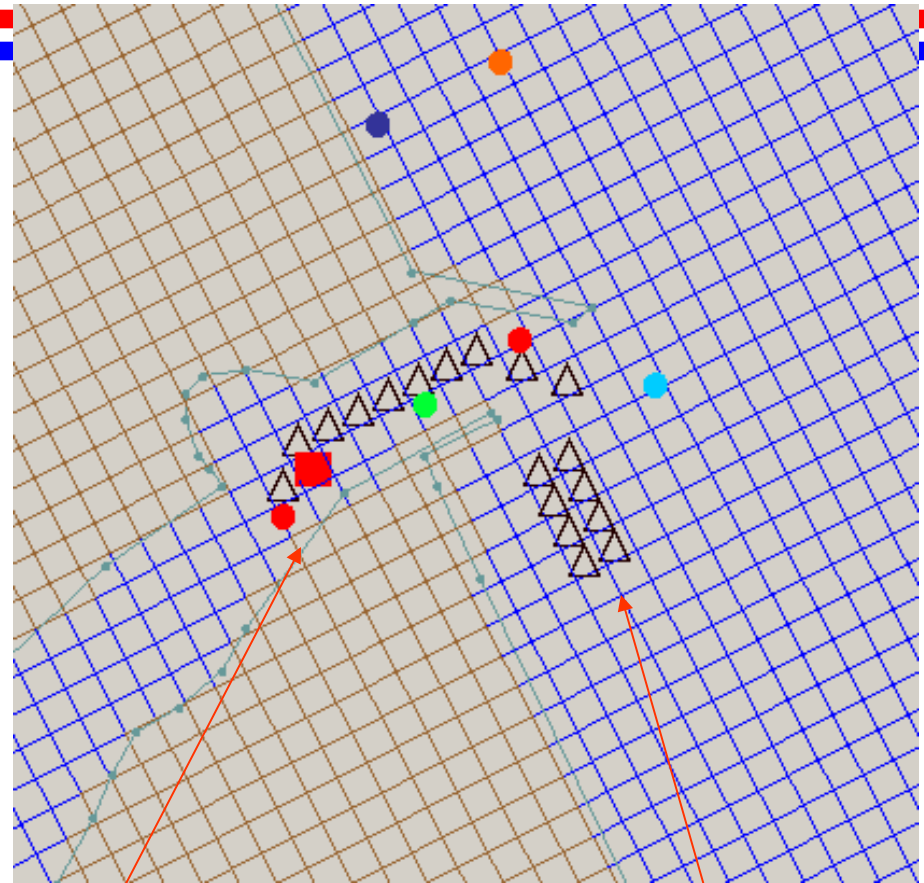
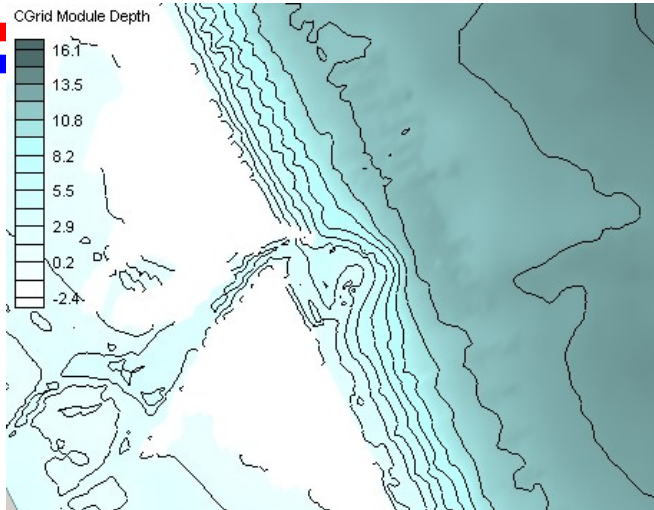
**Percent
Exceedance
of Current
Speed**



Sebastian Inlet, Florida

M2D run for January - May 1997

Hard Bottom Cells to Represent Coquina Rock



Channel (10 cells)

Reef rocks (8 cells)

Grid cells are 50 m by 50 m

Grays Harbor, WA ^N Breach -- Application

PACIFIC OCEAN

OCEAN SHORES

DAMON POINT

NORTH JETTY

GRAYS HARBOR INLET ENTRANCE

HALF MOON BAY

SOUTH JETTY

WESTPORT

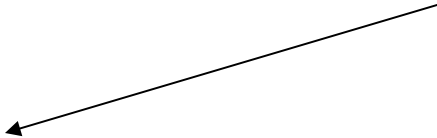
Breach

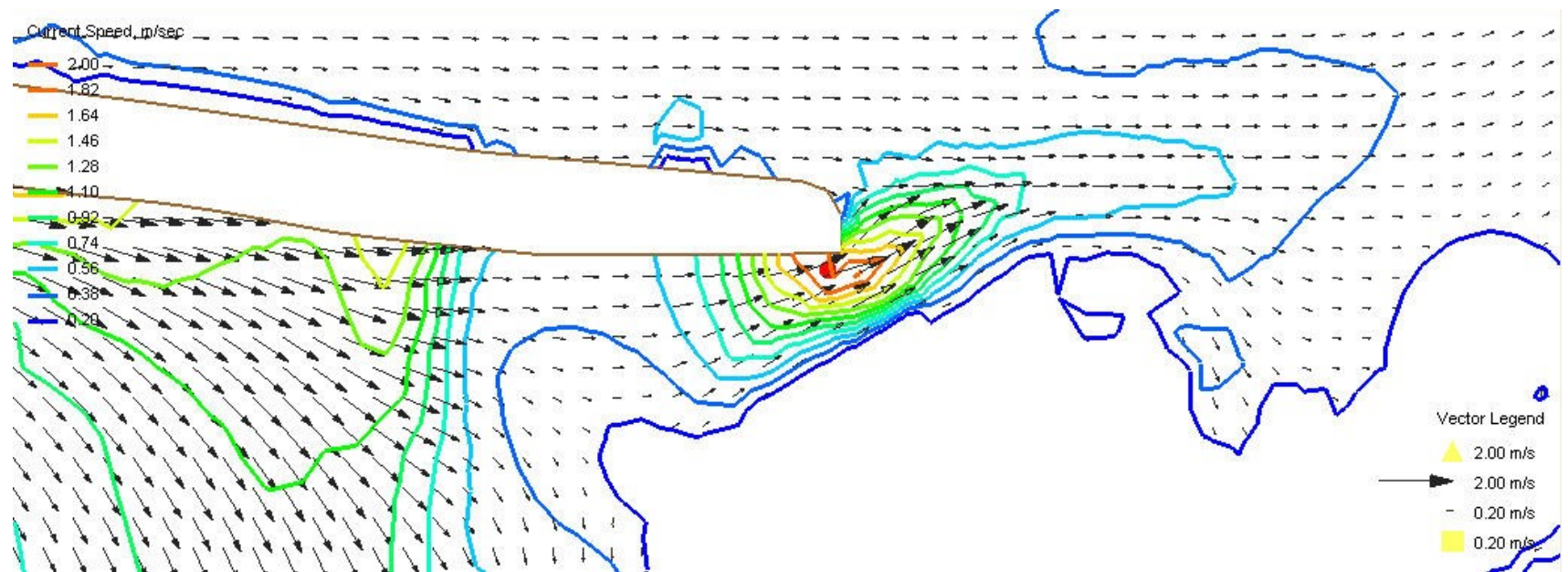
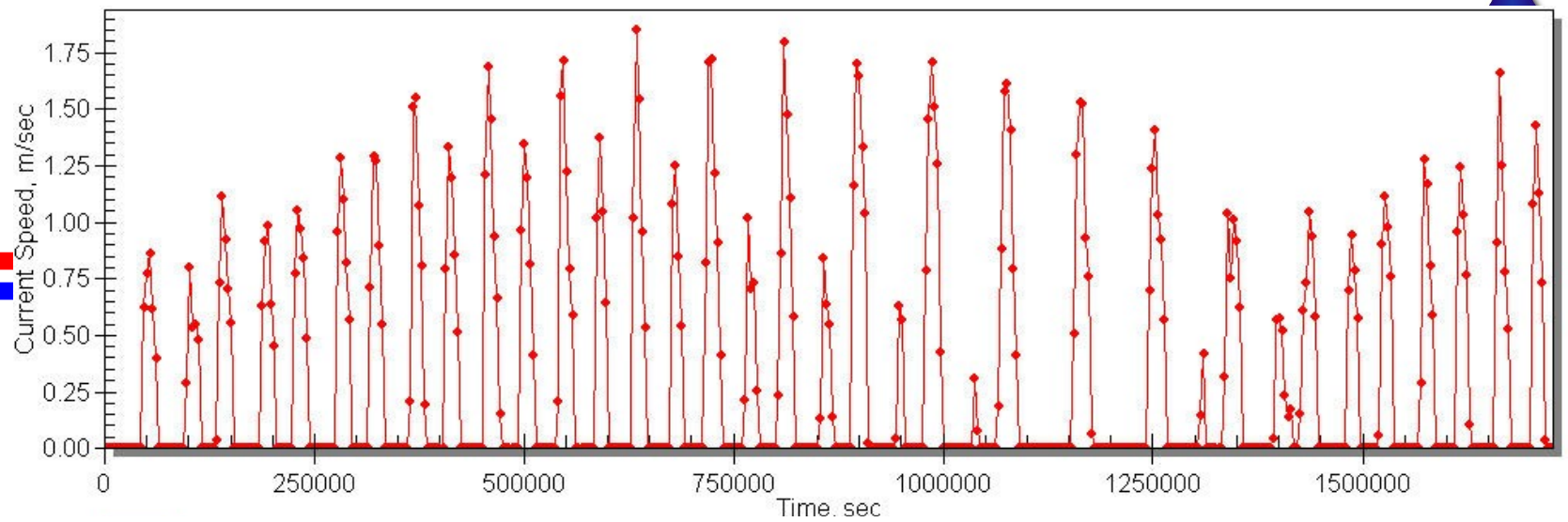


Initial Breach (December 1993)



Half Moon Bay

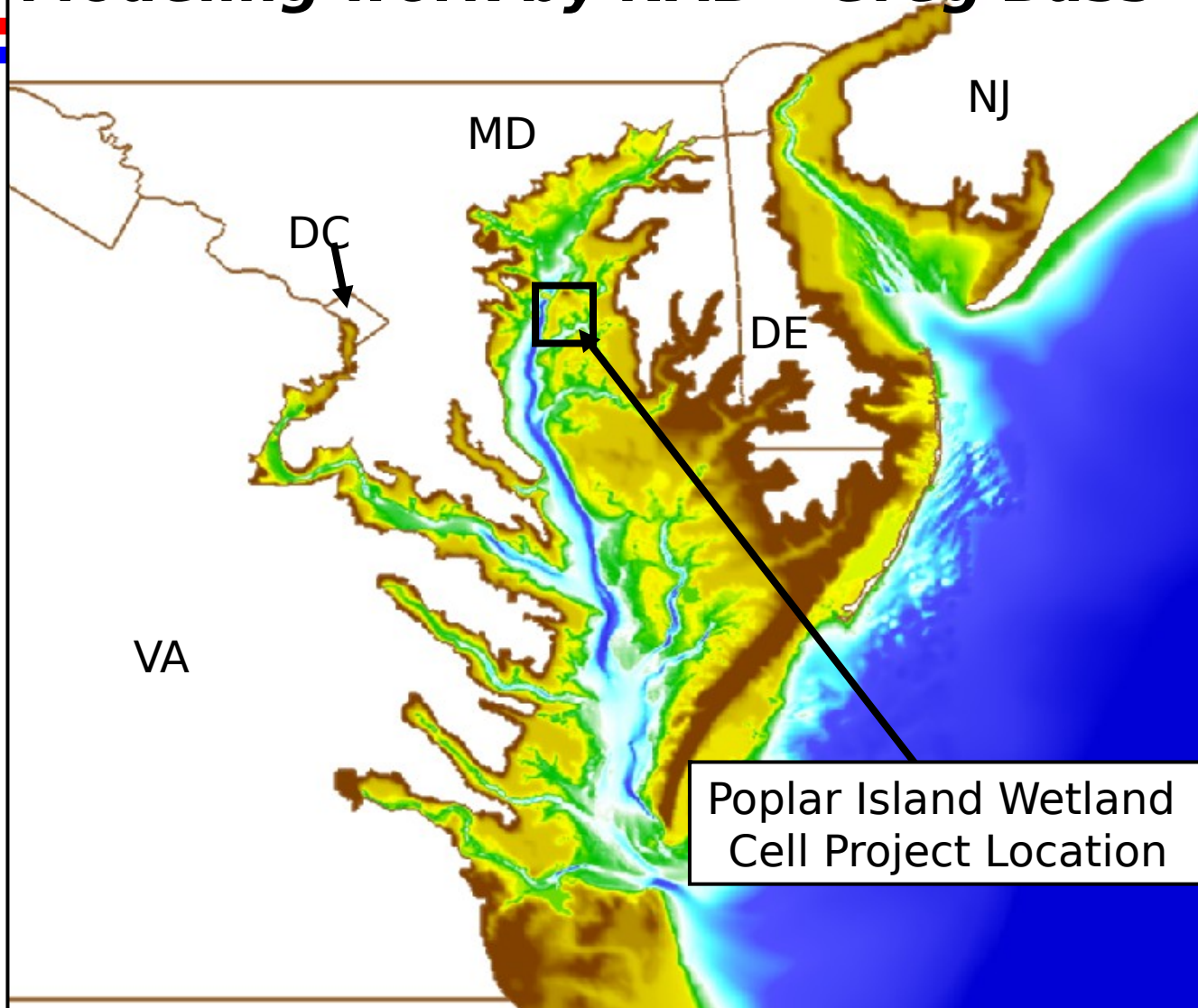




WU 2. Inlet Bypassing & Nearshore Berms

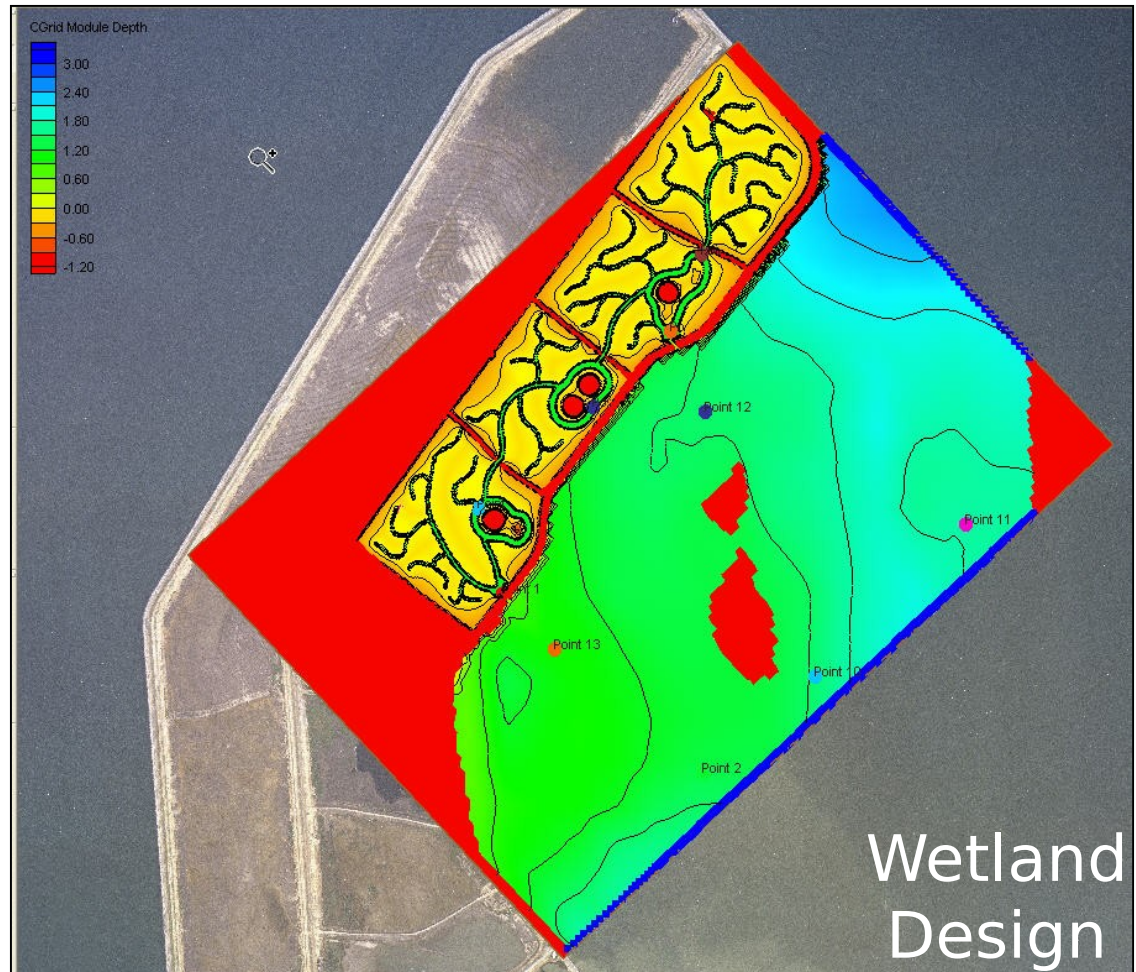


M2D Modeling work by NAB - Greg Bass



WU 2. Inlet Bypassing & Nearshore Berms

M2D - Developing Poplar Island Grid in SMS

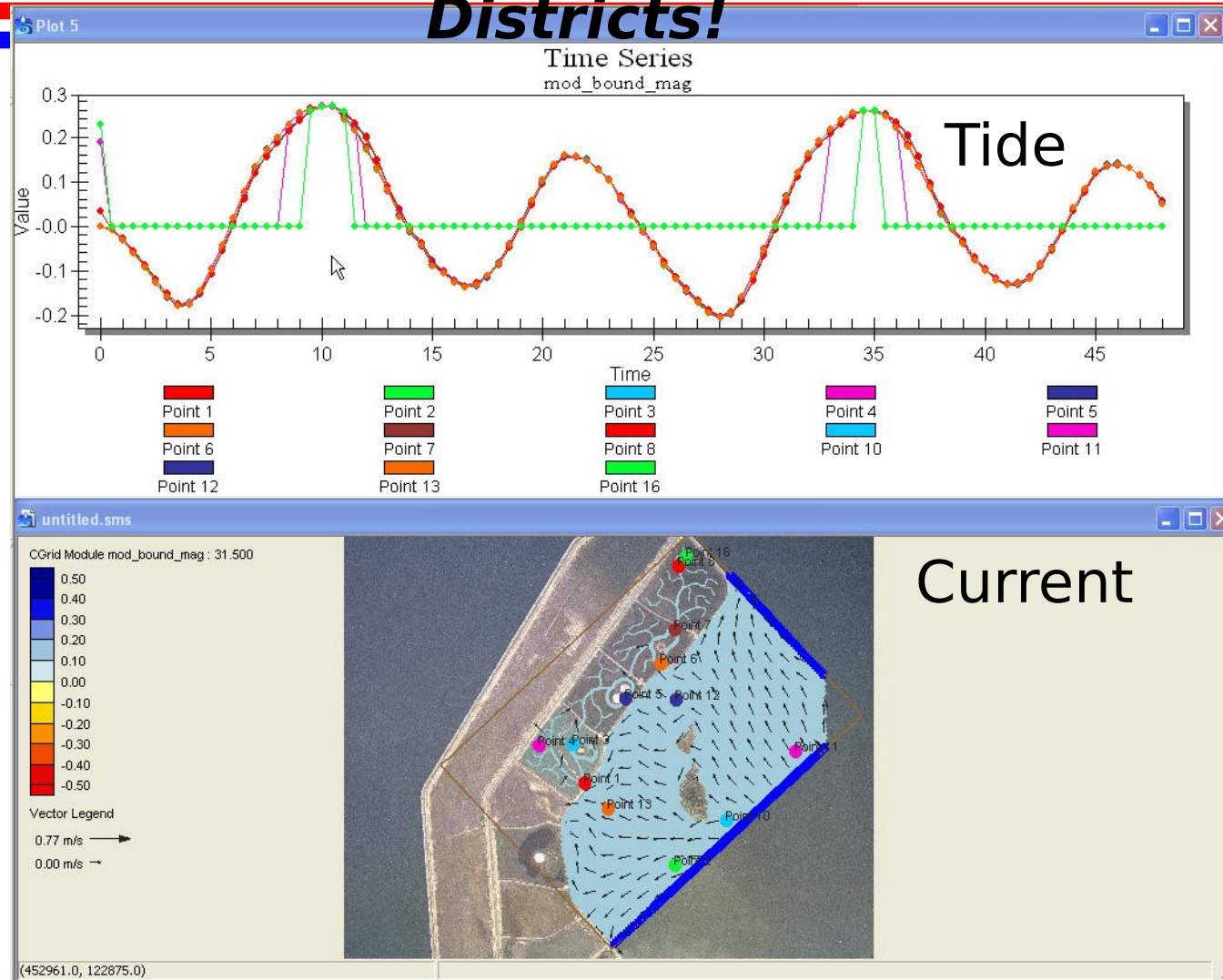


WU 2. Inlet Bypassing & Nearshore Berms

IMS-M2D Technology being applied by

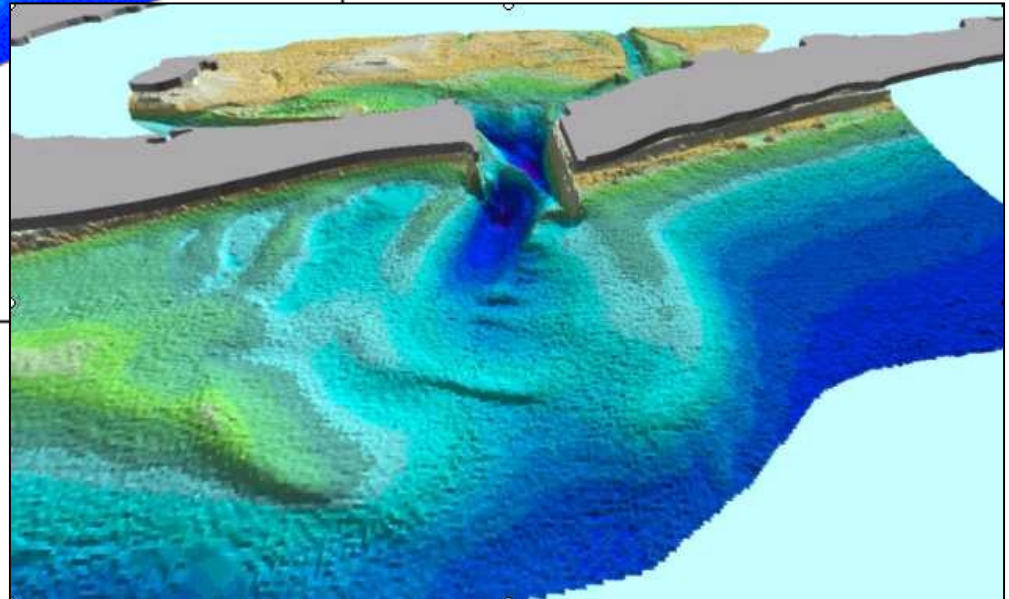
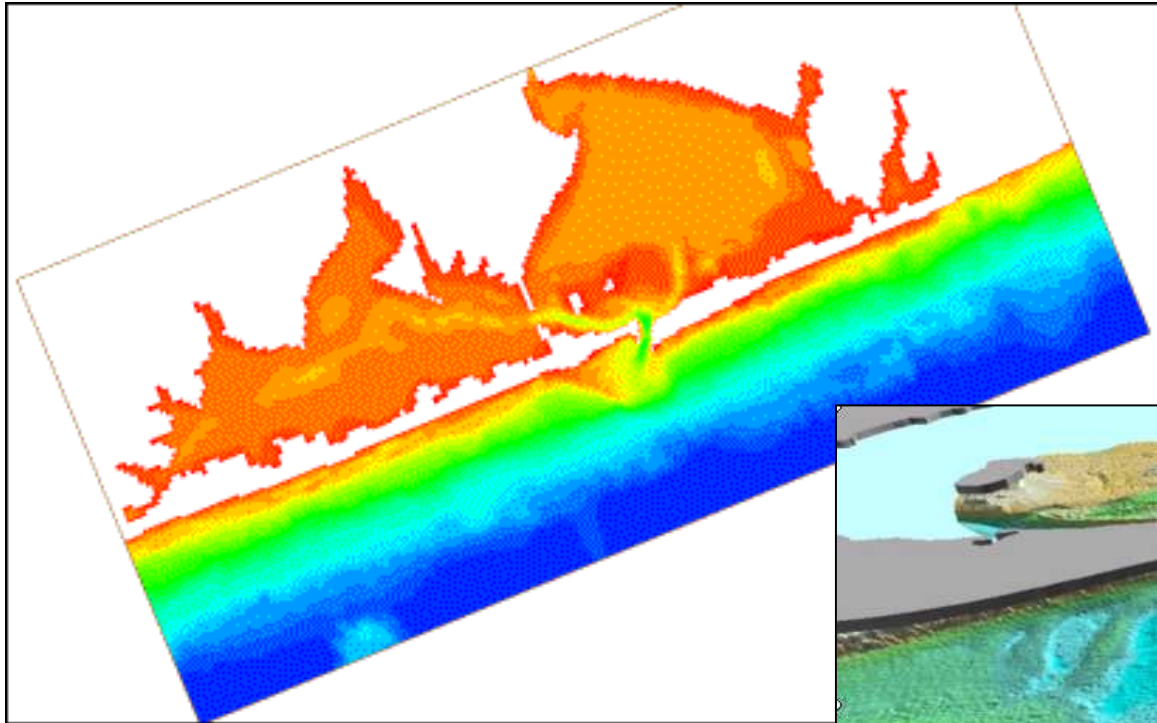


Districts!



WU 2. Inlet Bypassing & Nearshore Berms

M2D Demo at Break: Shinnecock Inlet, NY



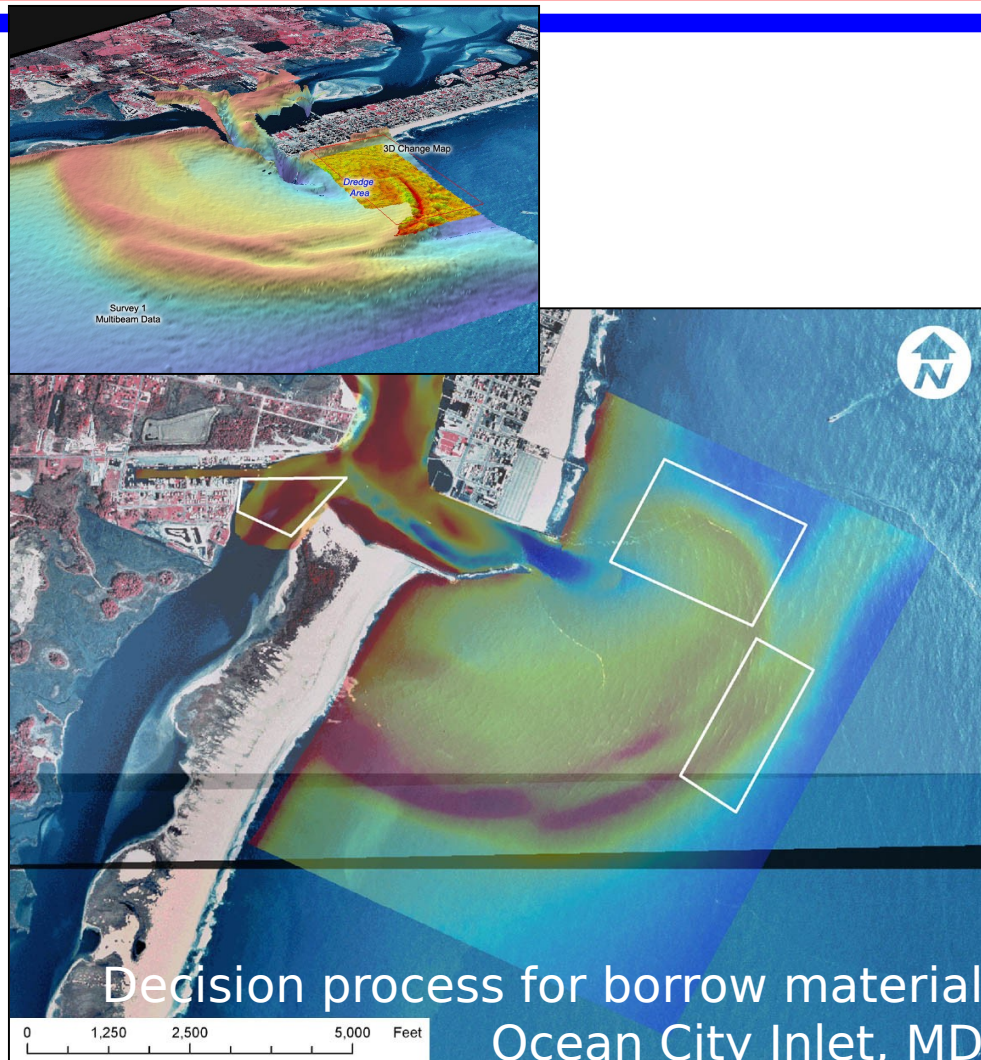
WU 3. Inlet Geomorphic Evolution

Ken Connell, Nick Kraus



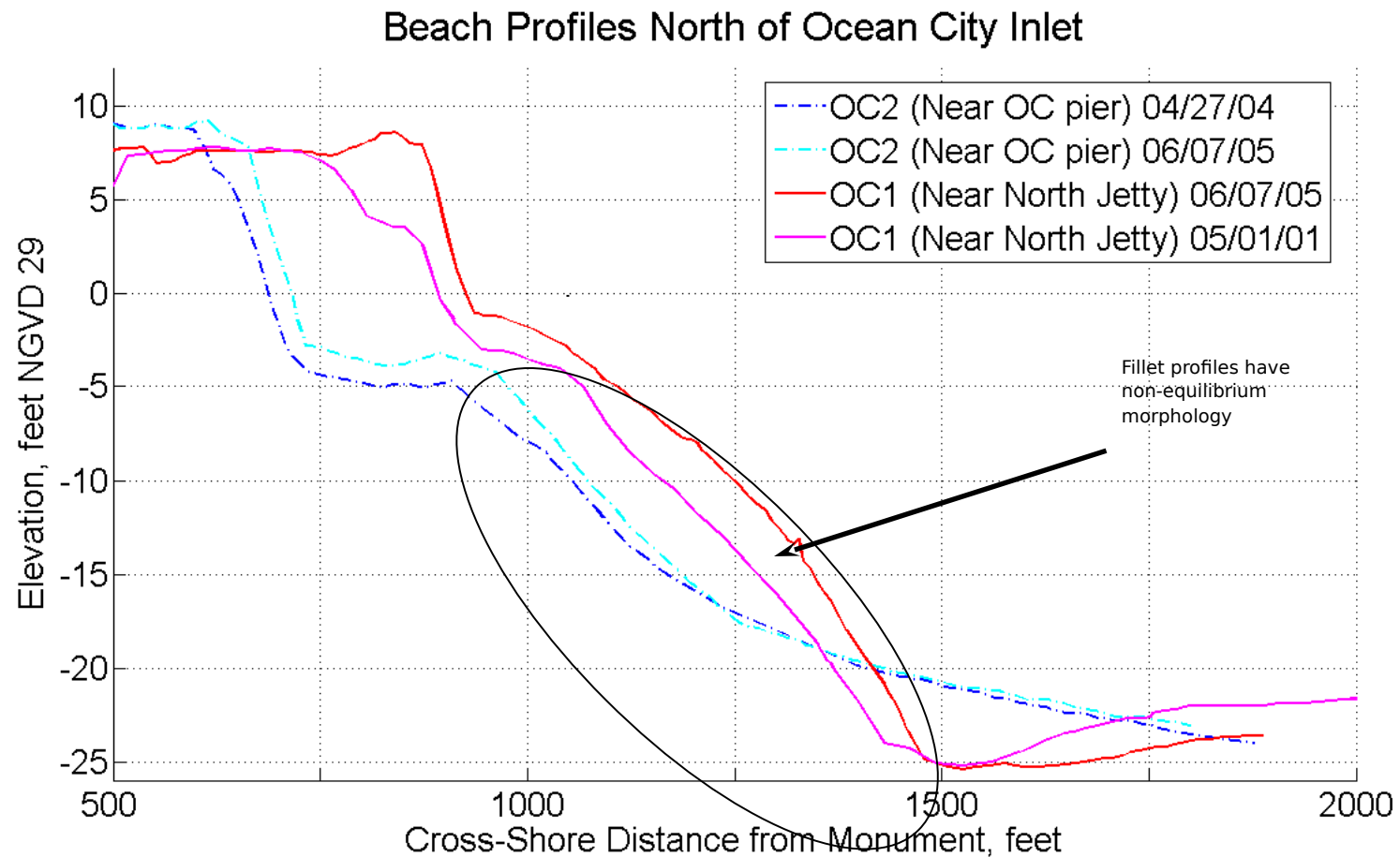
Need: Many Federal inlets > 100 years old, and morphology has greatly changed. Inlet modifications will permanently change coastal morphology, & O&M will be carried out with that morphology.

Approach: Develop tools and guidance to predict morphologic evolution due to O&M over long temporal and spatial scales.



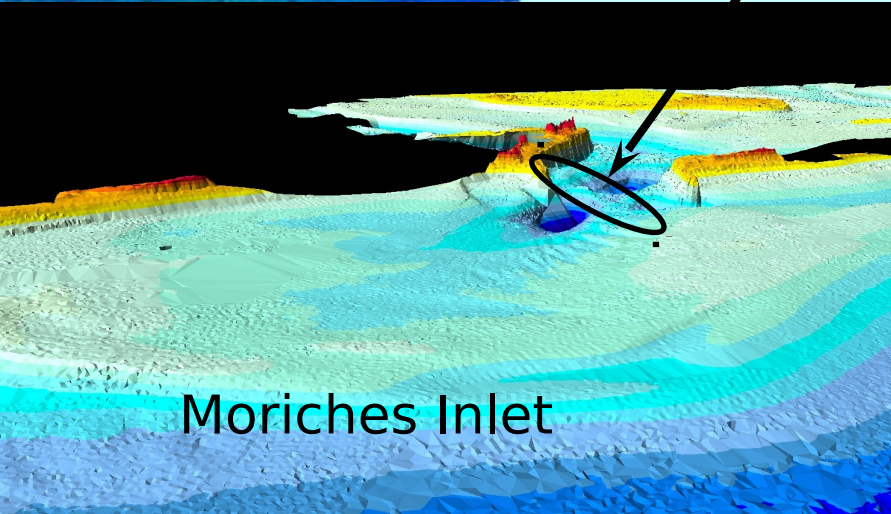
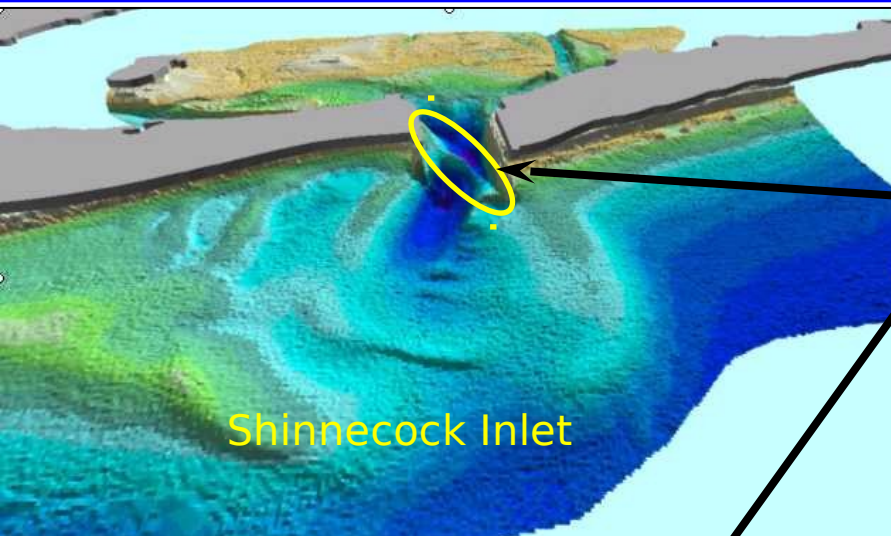
WU 3. Inlet Geomorphic Evolution

Morphology Change

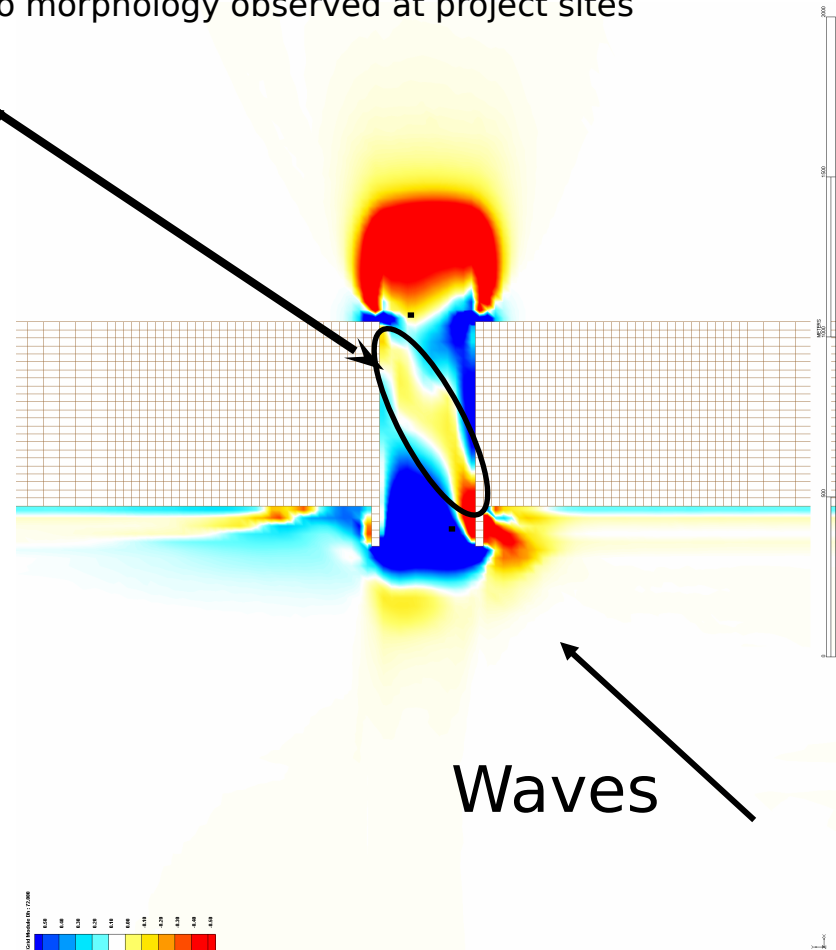


WU 3. Inlet Geomorphic Evolution

Morphology Change



Braided morphology after 72 hr in idealized inlet similar to morphology observed at project sites

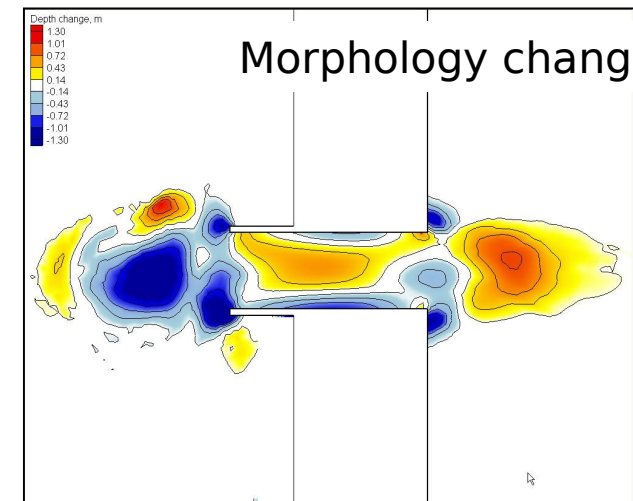
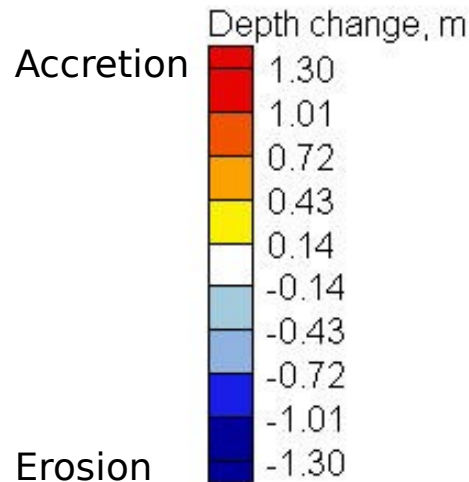
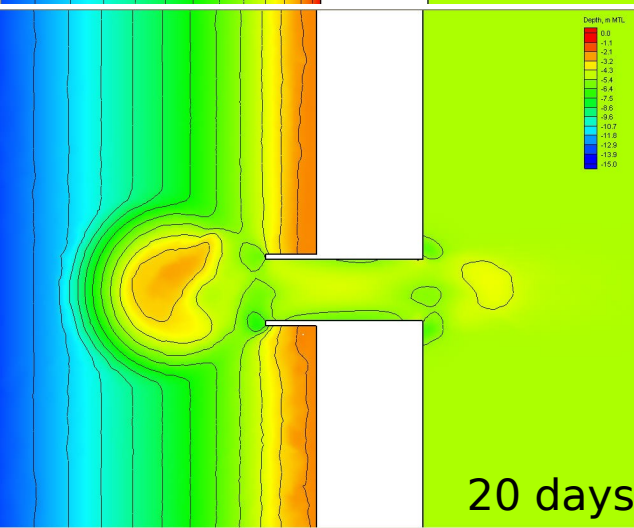
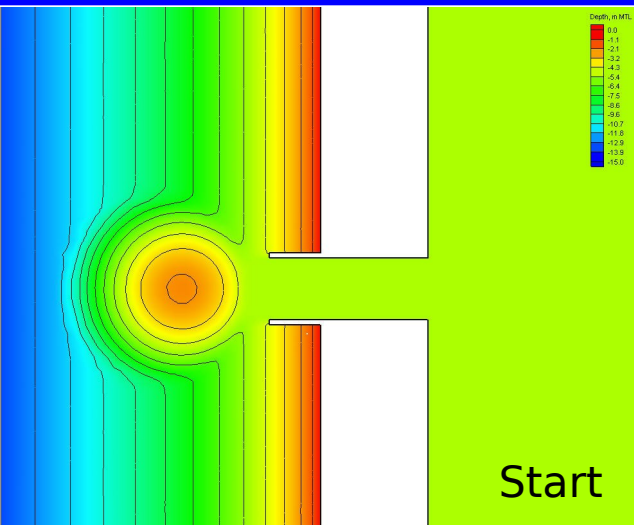


WU 3. Inlet Geomorphic Evolution

Sensitivity Testing



Model simulations of idealized inlets help examine process applications under controlled conditions



WU 3. Inlet Geomorphic Evolution

CIRP Cooperative R & D



CIRP-SWWRP Supported Projects

- Breaching processes – Stranded Jetties & New Inlets
- Reservoir model – Inlet Shoal evolution



**Ocean City Inlet,
MD 06 Nov 1999**



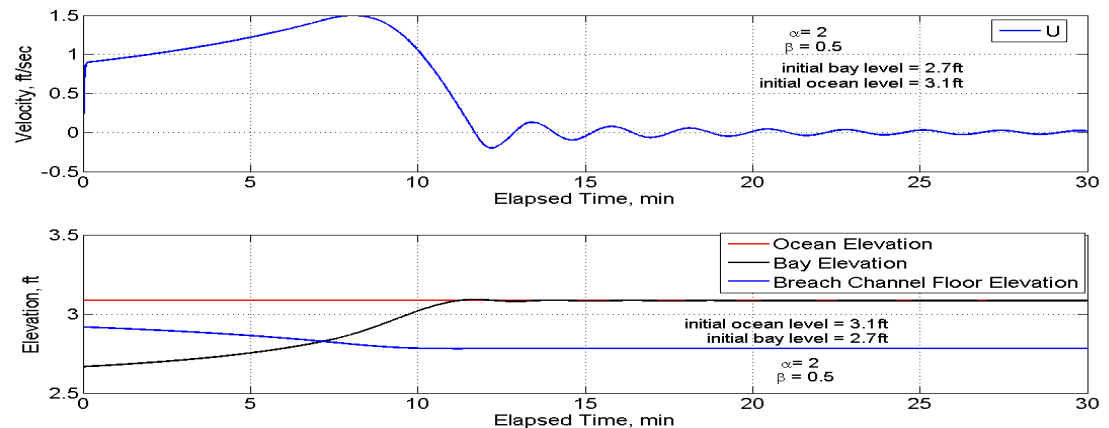
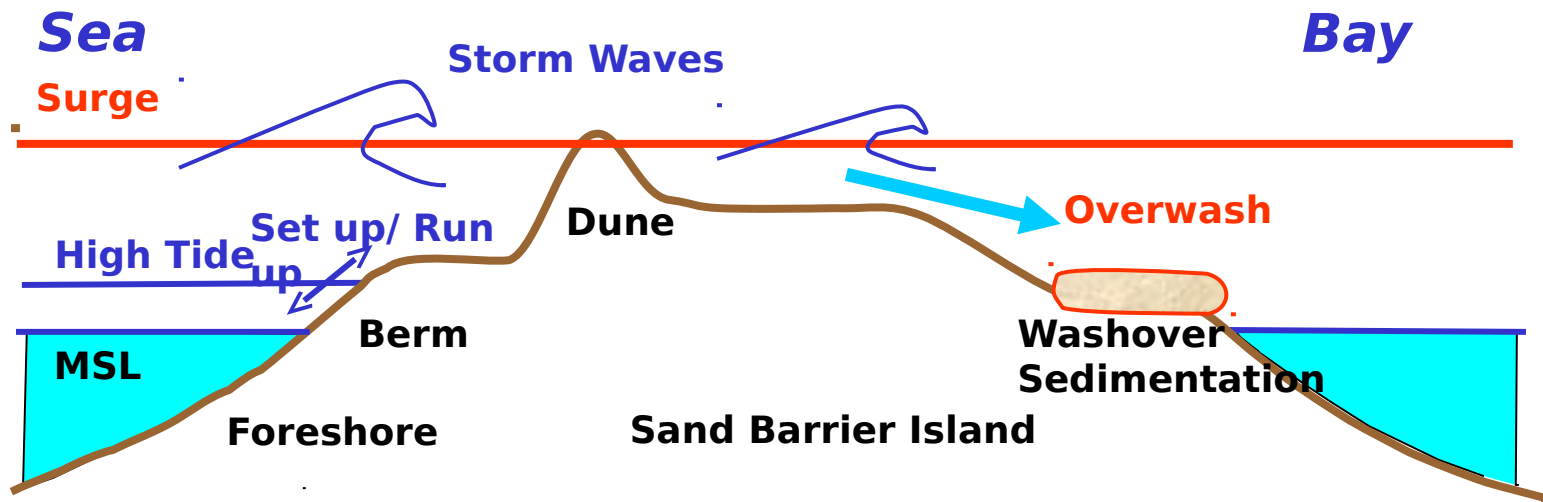
**Mansfield Pass,
TX 13 Jan 2005**



**Grays Harbor Breach,
WA
Dec 1993**

WU 3. Inlet Geomorphic Evolution

Modeling Barrier Island Breach Processes



WU 4. Validation of Predictive Technology

Julie Rosati



Need: Validate CIRP models & tools at reconnaissance, feasibility, and design levels. Solve O&M problems common to Corps projects.

Approach:

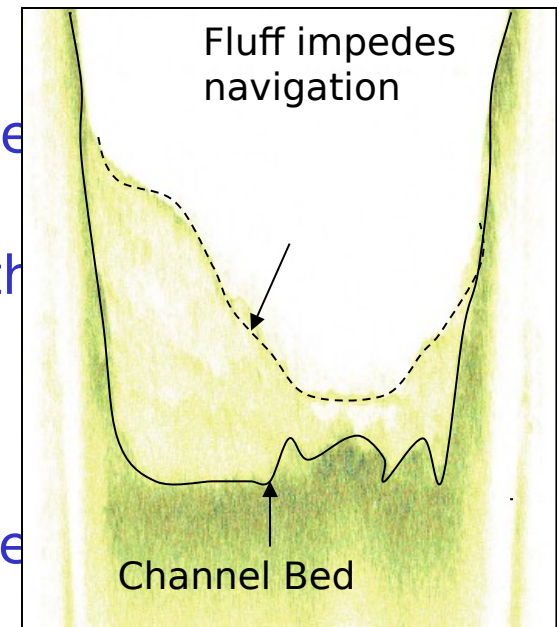
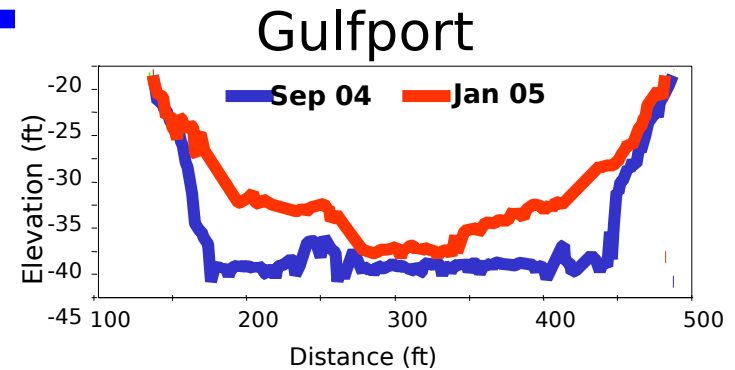
- Test CIRP's emerging technology at sites with critical District O&M concerns of broad applicability.
- Propose and evaluate solutions.
- Develop web-based decision-support tools for O&M actions and anticipated response.



WU 4. Validation of Predictive Technology *Focus Sites and O&M Concerns*



- Gulfport Harbor, MS
 - Rapid channel shoaling
- Ocean City Inlet, MD
 - Ebb shoal mining, channel scour, adjacent beach erosion
- Humboldt Entrance Channel, CA
 - Unanticipated rapid shoaling after deepening
- Columbia River, WA/OR
 - Massive river/estuarine/inlet system with O&M affecting adjacent beaches on large spatial and temporal scales
- Upper Matagorda Ship Channel, TX
 - “Fluff” = fine sediment shoaling; impedes navigation

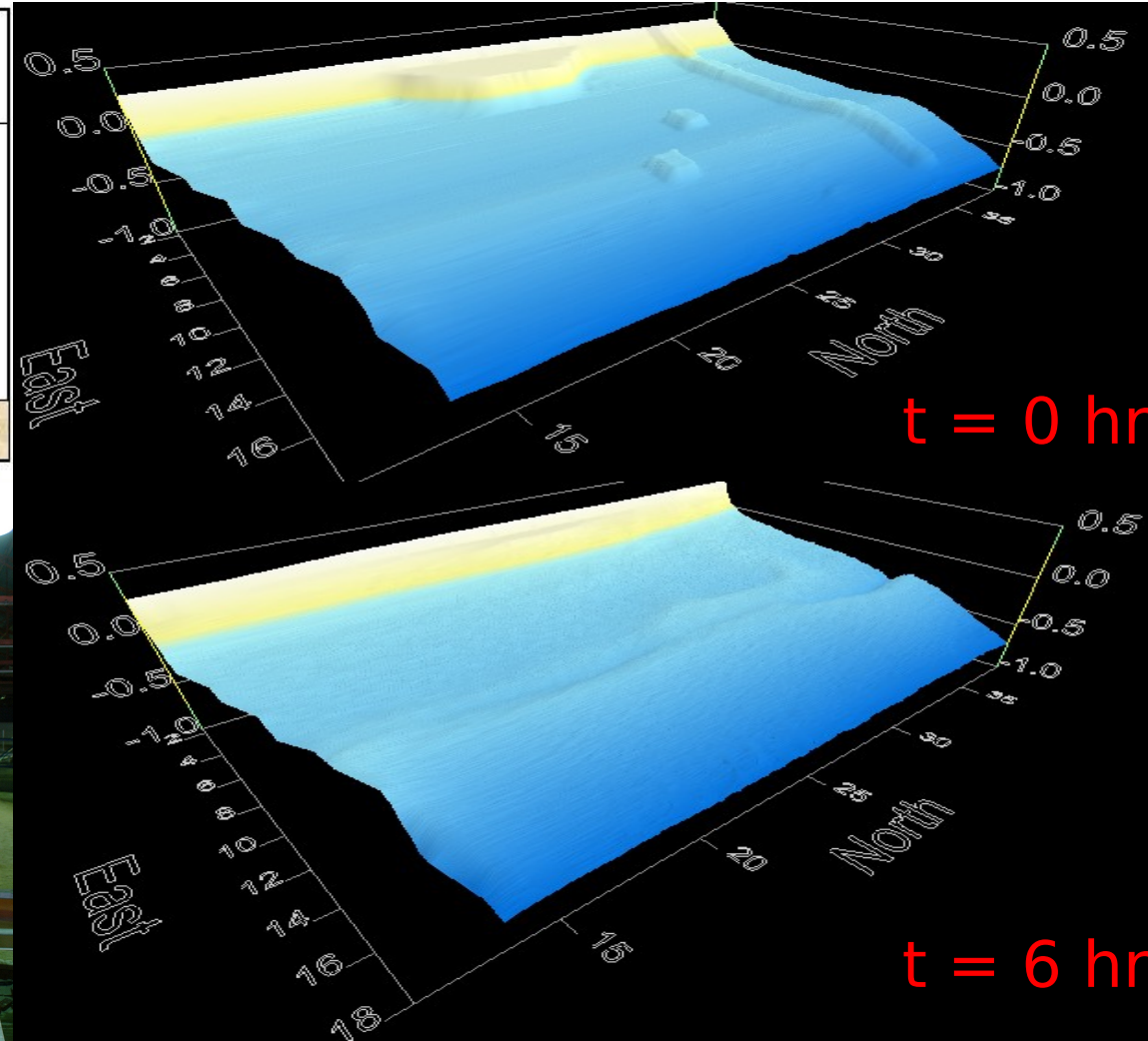
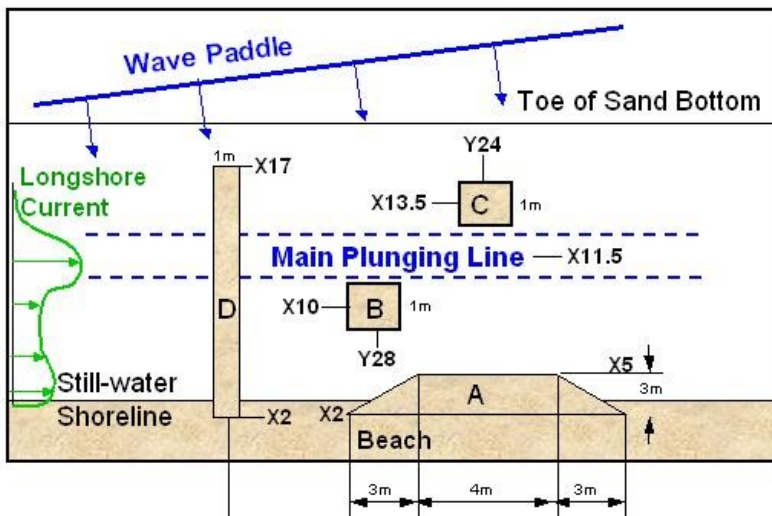


Matagorda

WU 4. Validation of Predictive Technology

Hard bottom Physical Model Tests

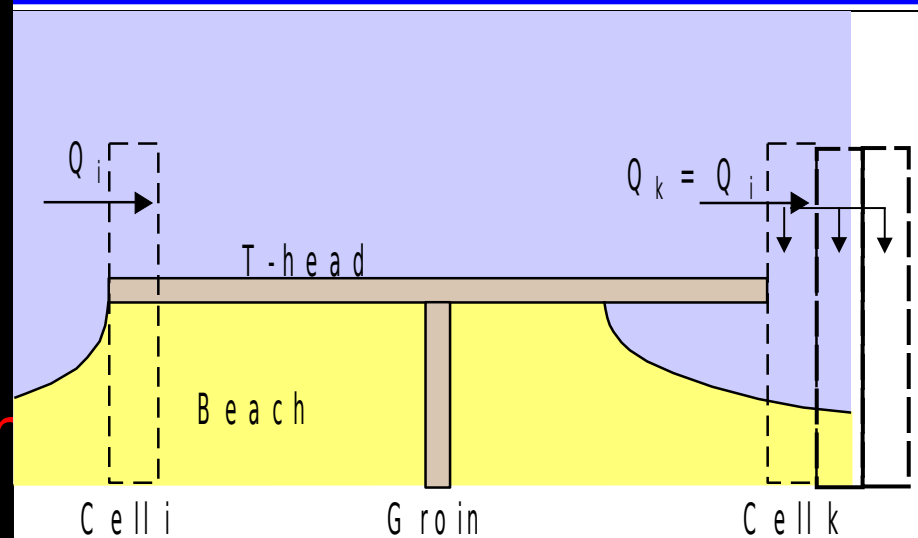
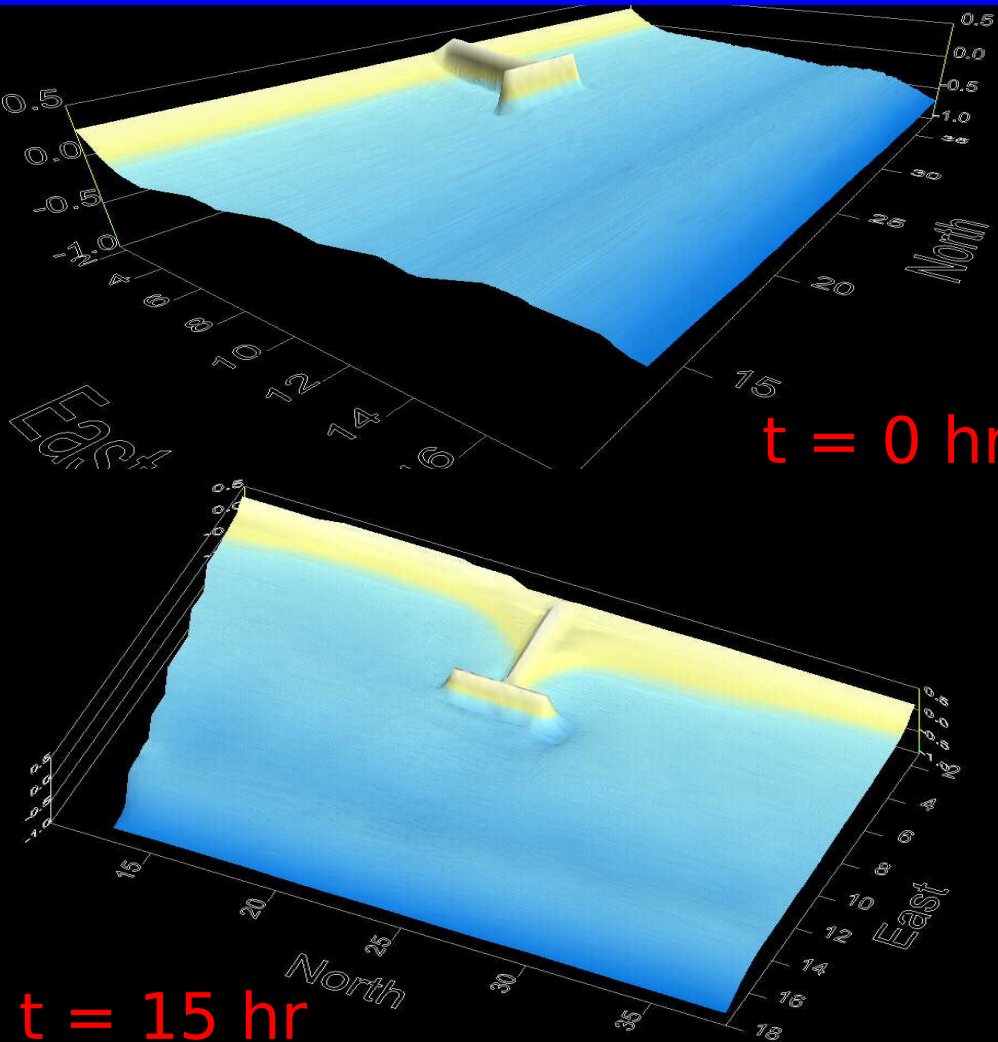
Validation Data for Morphology Change Numerical Models



WU 4. Validation of Predictive Technology

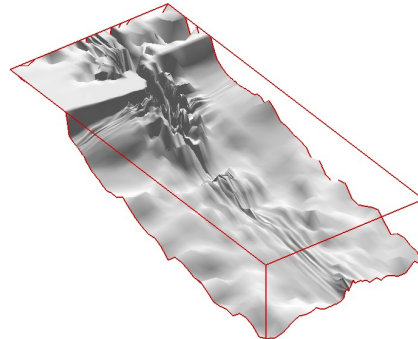
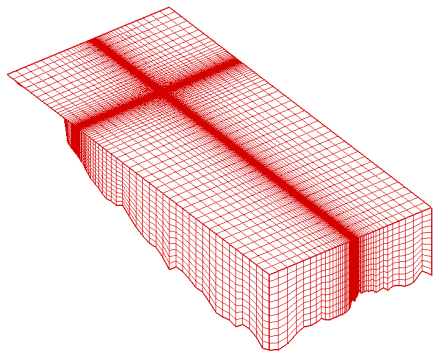
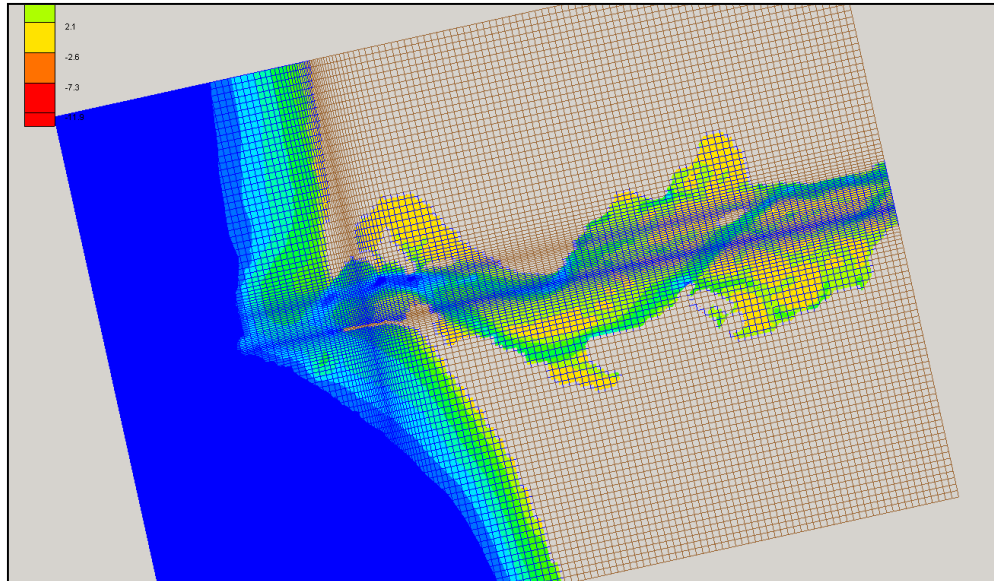
T-Groin Physical Model Tests

Development / Validation Data for GENESIS-T

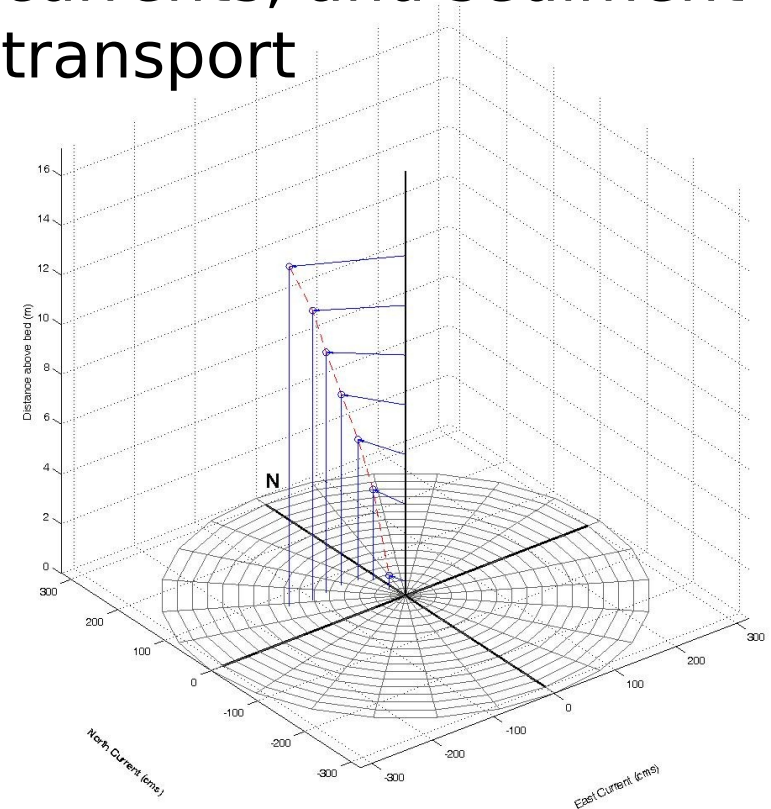


WU 4. Validation of Predictive Technology

*Applications of M3D at
Mouth of Columbia River, WA/OR*

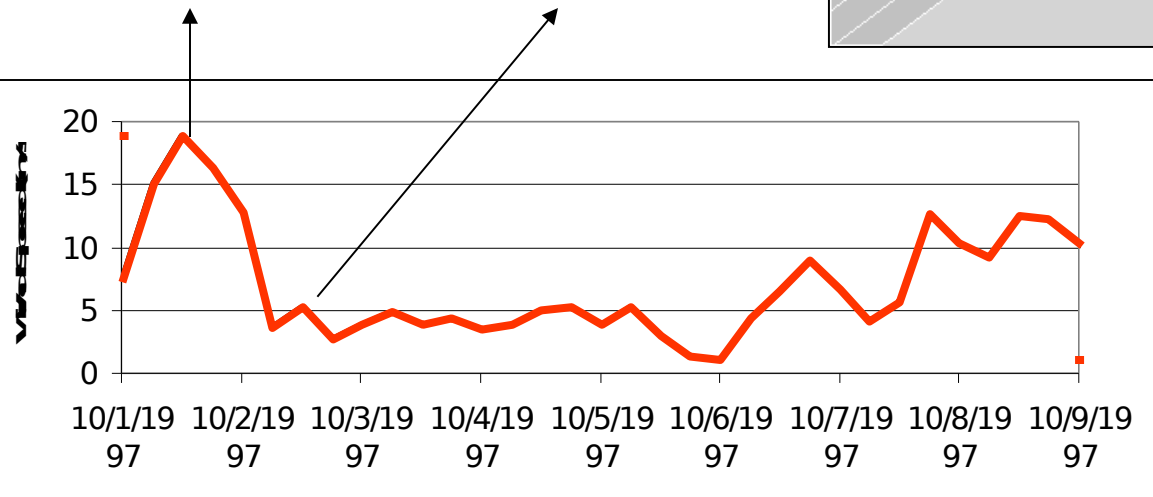
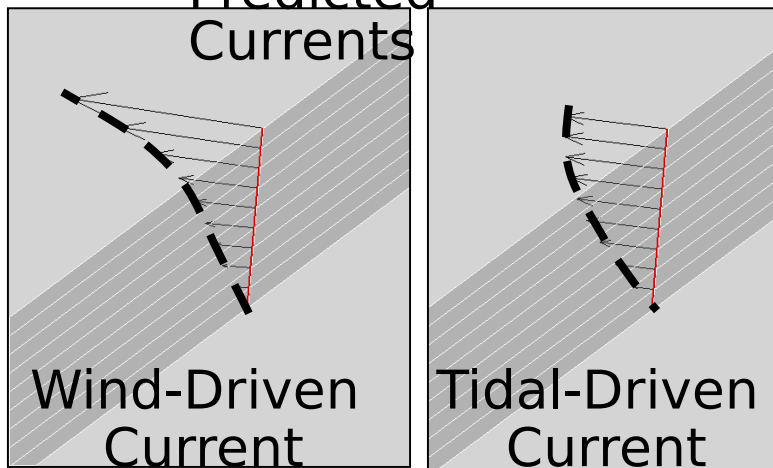


3-D Modeling of waves, currents, and sediment transport

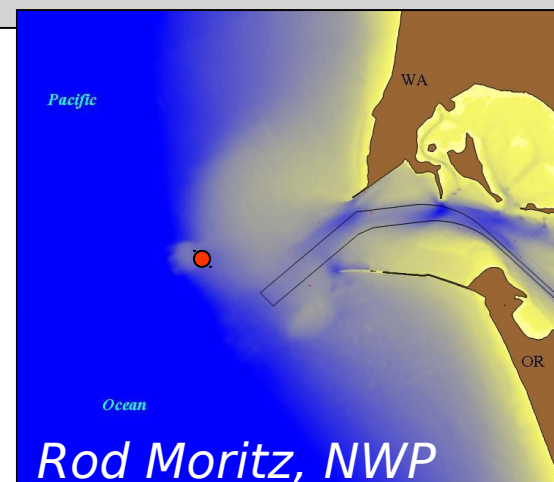
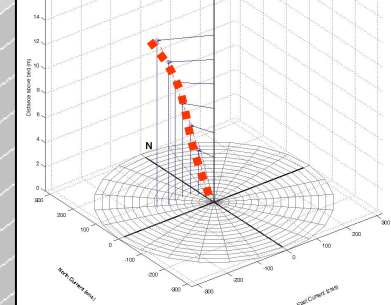


M3D Current Prediction Oct 1-10, 1997

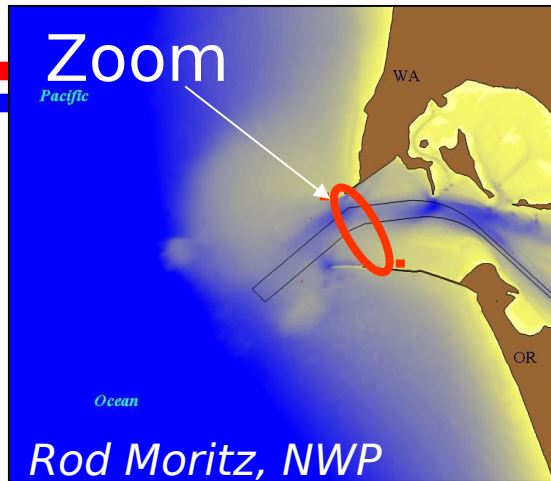
Predicted
Currents



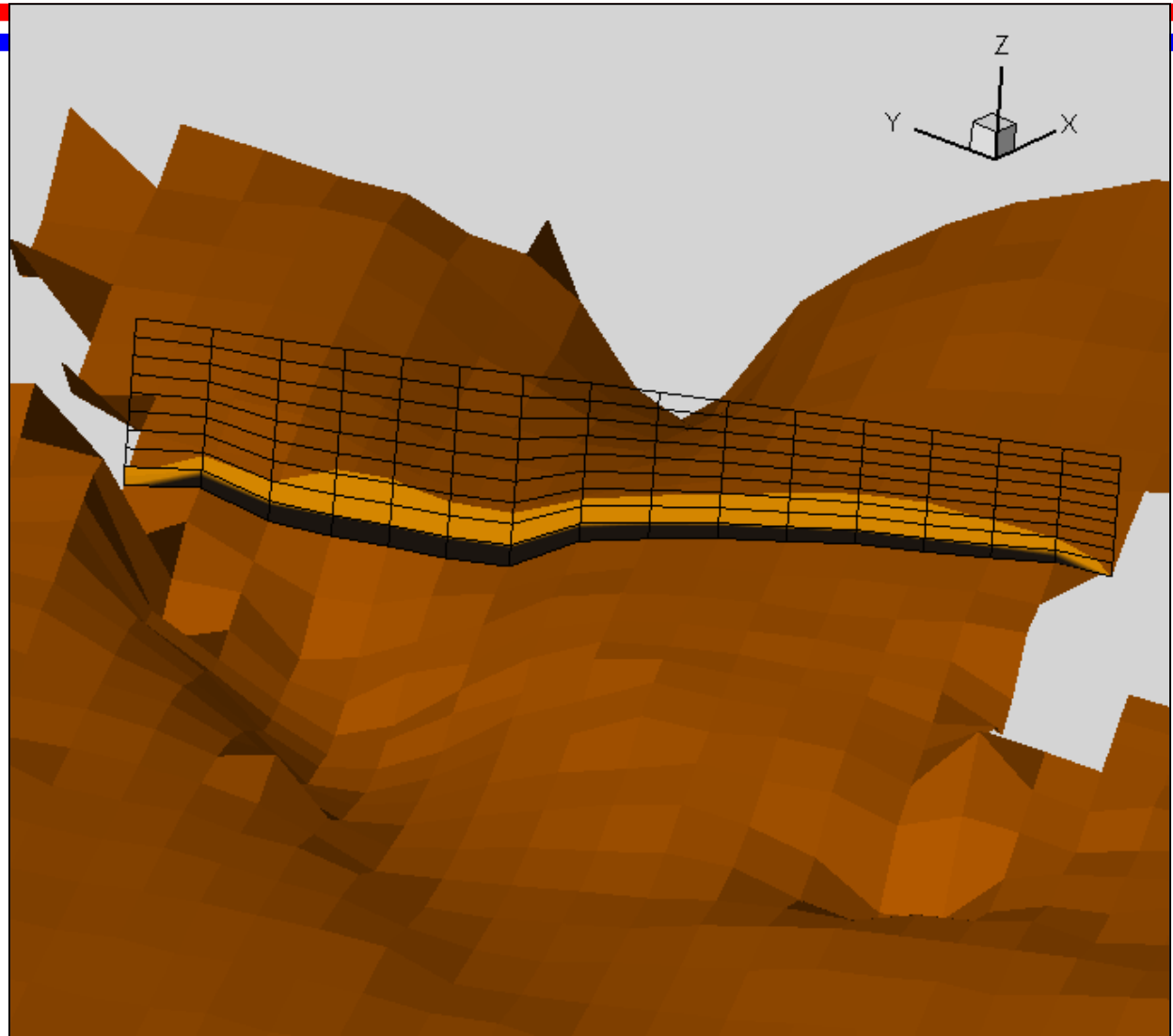
Measured
currents



M3D – MCR Suspended Sediment Transport Variation with Tides, River Flow, Waves, and Wind



Initially high rate
of
suspended
sediment across
channel due to
storm –
decreases
through time.

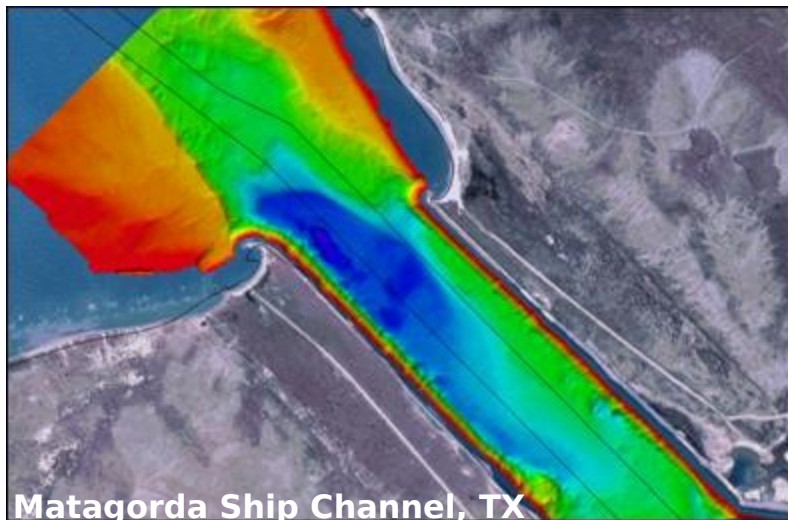


WU 5. Coastal Structure Asset Management

Steve Hughes, Jeff Melby



Need: Procedure to make objective evaluation and prioritization of O&M funding for repair, rehabilitation, and maintenance of critical coastal navigation infrastructure.

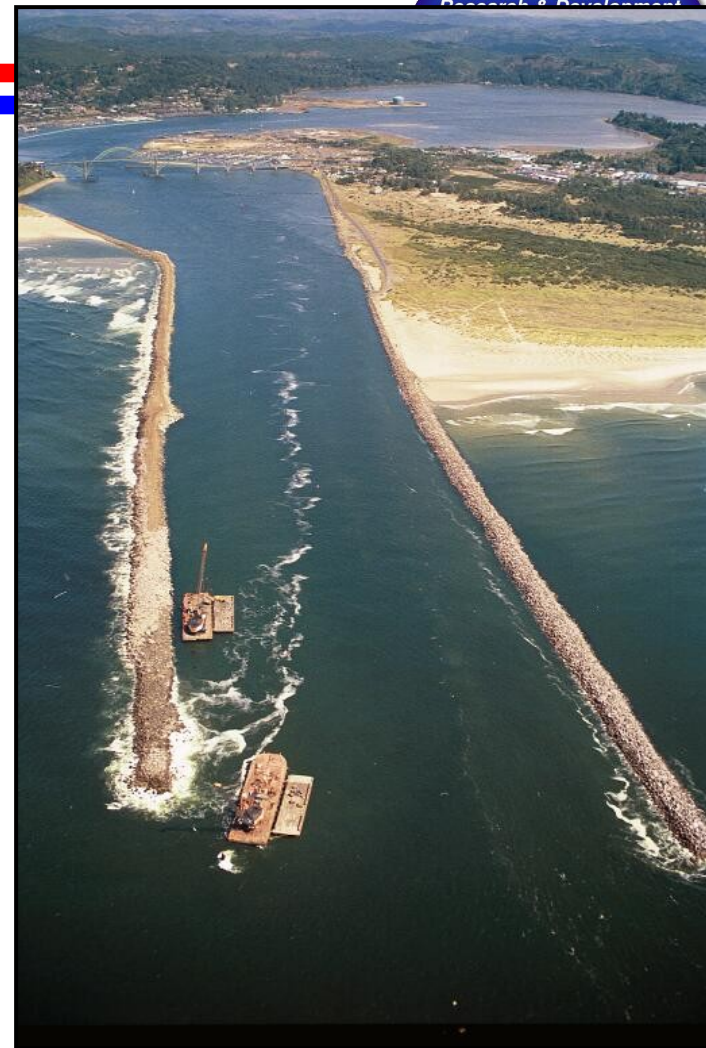


Approach: Update coastal structure design guidance and develop new procedures for using the guidance within the Asset Management Decision Tool – AMDT -- framework.

WU 5. Coastal Structure Asset Management



**Preventing scour near lighthouse
at Barnegat Inlet using marine
mattresses**



Repair of Yaquina North Jett

WU 5. Coastal Structure Asset Management



What's the Problem?

Problem:

- Tens of Millions \$ spent each year repairing structures
- Most structures are more than 50 years old (some >100 yr!)
- Not enough funding to cover the necessary repairs

Need:

- Rational method for assessing and prioritizing maintenance and repair of structures
- Methodology that is objective, balanced, and fair
- Useful at District, Division, and Headquarters levels

WU 5. Coastal Structure Asset Management



New CIRP Work Unit

Objectives:

- Develop **Asset Management Decision Tool** (AMDT) for evaluation of O&M funding of repair, rehab, maintenance of critical infrastructure
- **Archive data** on critical coastal structures into eCoastal database
 - Existing data (history, bathymetry, condition surveys,
 - New nearshore wave climatology
 - Condition surveys
- Update coastal structure **design guidance** for use in AMDT
- Incorporate new functionality guidelines related to **morphological** impacts

WU 5. Coastal Structure Asset Management



Identify Critical Structures (FY06 Major Task)

- Inventory important structures, cull to less than 200
- Develop selection criteria (March 06 workshop)
- Gather existing data to support selection
- Select most critical (less than 100) coastal structures (Summer 06)

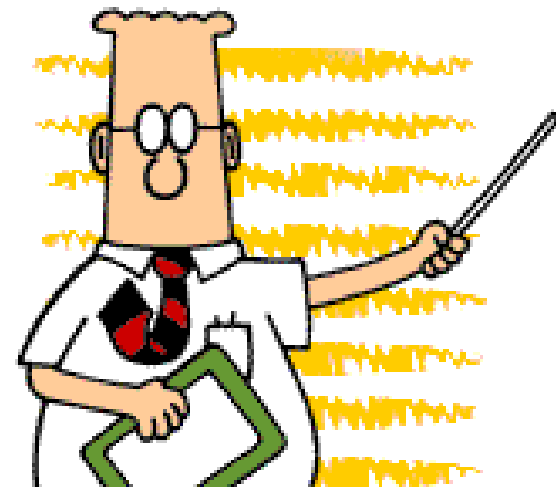
Mental exercise: If all your District's structures failed at the same time, which ones would you repair first?

WU 5. Coastal Structure Asset Management



Design Guidance Improvement

- Improve existing design guidance
 - Application within AMDT for risk analysis
 - Longer life for repaired structures
- Develop new design guidance
 - Identified for use in AMDT
 - Identified by PDT as needed guidance
 - Monitor literature for transitioning new developments into useful design guidance
- Joint effort with Jeff Melby's Navigation Program "Risk" WU



WU 5. Coastal Structure Asset Management



New Design Guidance



Marine mattress revetment at Cape May, NJ (Philadelphia District)



US Army Corps
of Engineers

ERDC/CHL CHETN-II-
SECOND DRAFT 25 October 2005

Uses for Marine Mattresses in Coastal Engineering

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PURPOSE: The Coastal and Hydraulics Engineering Technical Note (CHETN) described herein provides basic information on the Triton Marine Mattress System,¹ describes potential applications for marine mattresses in coastal engineering, and summarizes previous successful deployments of marine mattresses in projects by the U.S. Army Corps of Engineers and others.

DESCRIPTION OF MARINE MATTRESSES: Marine mattresses are rock-filled containers constructed of high-strength geogrid as shown in Figure 1. Geogrid panels are laced together to form mattress-shaped baskets that are filled with small stones similar to construction of gabions. The Triton Marine Mattress System was developed by the Tensar Corporation, manufacturer of the geogrid panels used to form the mattress. The system is not patented, and the mattresses could be constructed using similar geogrid product from another manufacturer. But as of the date of this CHETN, all mattress applications in the United States have been made using Tensar geogrid.

Typical width for a single marine mattress is about 5 ft, but this can vary according to placement plan and contractor capability. Mattress lengths vary up to a recommended maximum of 35 ft. Mattress thickness is usually between 8 and 12 in. for revetment applications, but thicknesses can vary between 4 in. for bedding layers up to 24 in. for heavy-duty applications exposed to waves and currents. Assuming the stone fill has a volumetric weight of about 110 lb/cu ft, a 35-ft-long, 5-ft-wide, 1-ft-thick mattress weighs approximately 9.6 tons. The high-strength geogrid has sufficient strength to permit rock-filled mattress up to 35 ft in length to be hoisted from one end for placement at the project site. However, keep in mind this guidance is for mattresses 12 in. thick or less. Check with the geogrid manufacturer for maximum mattress lengths associated with mattresses thicker than 12 in. and widths of about 5 ft. Figure 2 shows a stack of marine mattresses prior to placement. Figure 3 shows lifting of a mattress from both ends. The cellular construction of the mattress using internal diaphragms maintains the uniform thickness of the stone fill material during the lifting and placement operations.

¹ This CHETN attempts to provide a balanced description of the Triton Marine Mattress System and how the product can be used on coastal projects. This technical note should not be considered an official Corps of Engineers endorsement or recommendation of the Triton Marine Mattress System or of the private company Tensar Earth Technologies, Inc., that manufactures the geogrid panels.

WU 5. Coastal Structure Asset Management



Marine Mattress Applications

- Revetments (low to moderate waves)
- Rubble-mound under-layers
- Toe protection
- Scour mats
- Foundation and bedding mats
- Pipeline/outfall protection



Marine mattress toe protection at Seabrook, NH (Section 227 project)

WU 5. Coastal Structure Asset Management



Products and Benefits

Database of critical coastal structures

Benefit: Permanent archival database will be easily updated. Provides needed information for the AMDT. Database will capture Corps knowledge about its critical structures. Application within AMDT for risk analysis.

Asset Management Decision Tool

Benefit: Coordinate O&M budgeting process at all levels. Assure an objective project ranking with best return on investment.

Structure design guidance

Benefit: District and Division offices will have better design guidance yielding more robust and cost-effective designs and repairs

WU 5. Coastal Structure Asset Management



Time Frame

- **FY06**

- Establish eCoastal GIS system
- PDT workshop (Mar 06)
- Criteria for critical structure selection
- Selection of critical infrastructure (Summer 06)



- **FY07**

- Initial eCoastal entry for Atlantic coast (NAD, SAD)
- PDT meeting to finalize AMDT framework + eCoastal training
- Initial eCoastal entry for Gulf coast and Great Lakes (SAD, LRD, MWD, SWD)
- Initial eCoasts entry for Pacific coast (SPD, NWD, POD)

- **FY08**

- Wave climatology for Atlantic coast
- First version of AMDT with application to FY07 O&M as test
- PDT meeting to evaluate AMDT + training
- Wave climatology for Gulf coast and Great Lakes
- Wave climatology for Pacific coast

New CIRP Work Unit

WU 6. Navigation Simulation System

Zeki Demirbilek



Need: more accurate prediction of wave-structure and wave-ship interactions required.

Approach: improve modeling -

- Detailed wave transformation
- Wave, current, & structure
- Wave runup & overtopping of structures.
- Vessel-induced wakes & currents.
- Vessel & channel interaction.



*Global Explorer inbound
on Columbia River*

WU 6. Navigation Simulation System

Advantages of INWave



INlet Wave (**INWave**) Modeling System will supplement physical model and ship simulator navigation studies:



- Less costly to design and “construct.”
- Faster to evaluate design variations.
- Improved representation of physical processes.
- Increased range of simulated conditions.

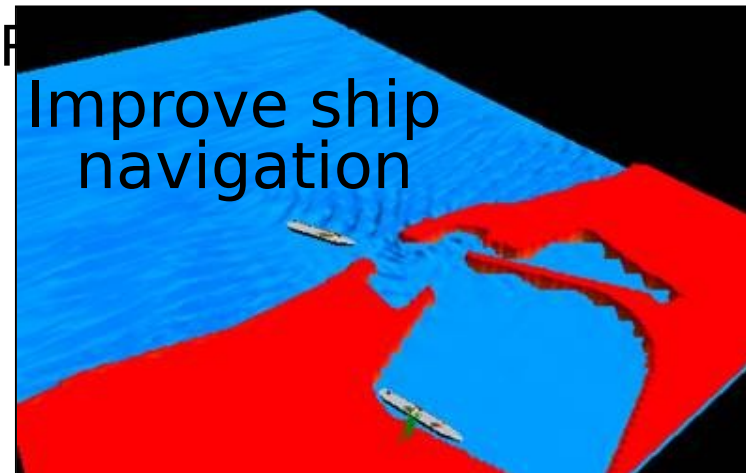
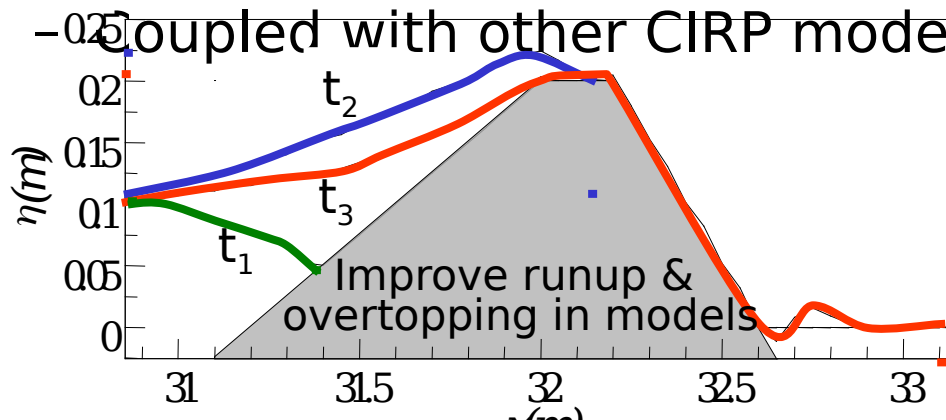
WU 6. Navigation Simulation System Products



Comprehensive wave-structure interaction modeling system, including:

- 3-D modeling of wave runup, overtopping, transmission, scour, and foundation liquefaction.
- Improved ship transit, maneuvering, navigation risk, and ship-wake impacts on waterways and shorelines (with Nav Systems).
- Particle Tracking Model (with DOE)

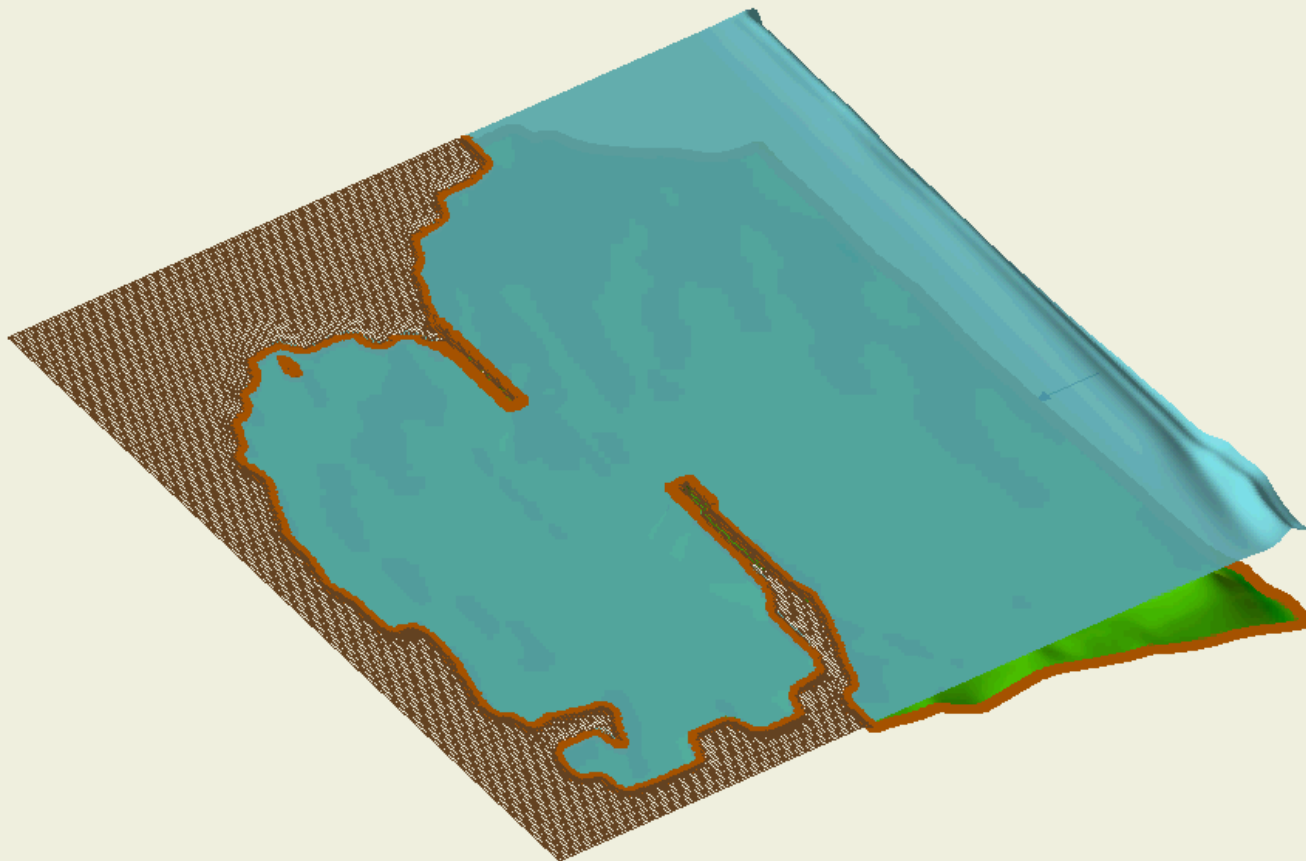
- Coupled with other CIRP models.



WU 6. Navigation Simulation System

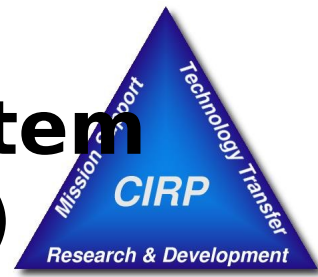
Example of Wave Impact on Port

19.75

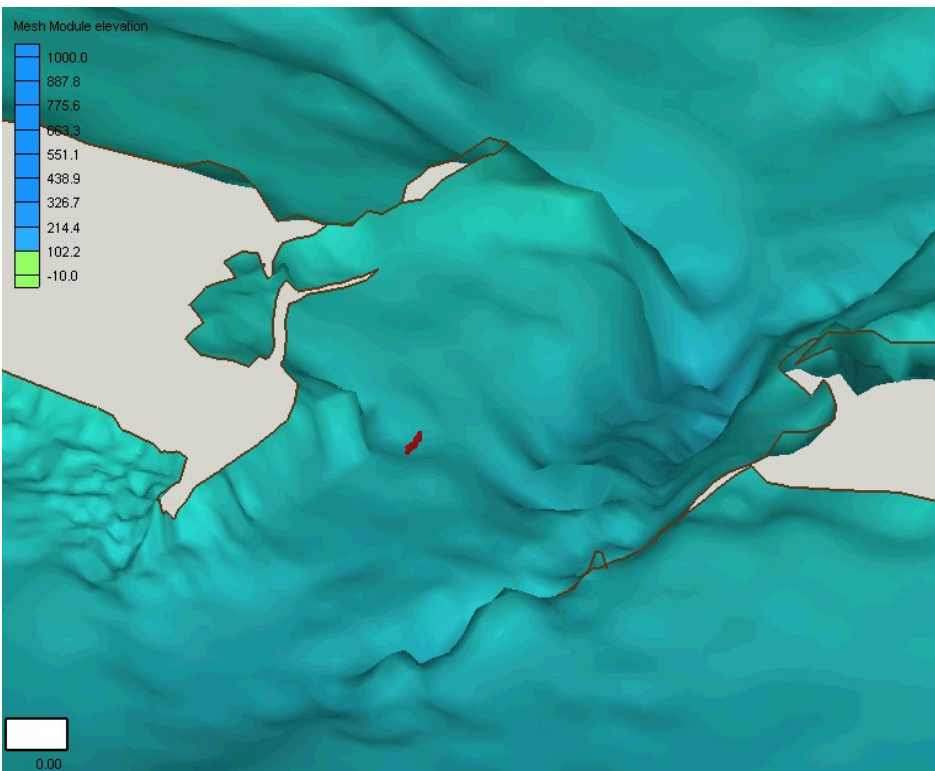


WU 6. Navigation Simulation System

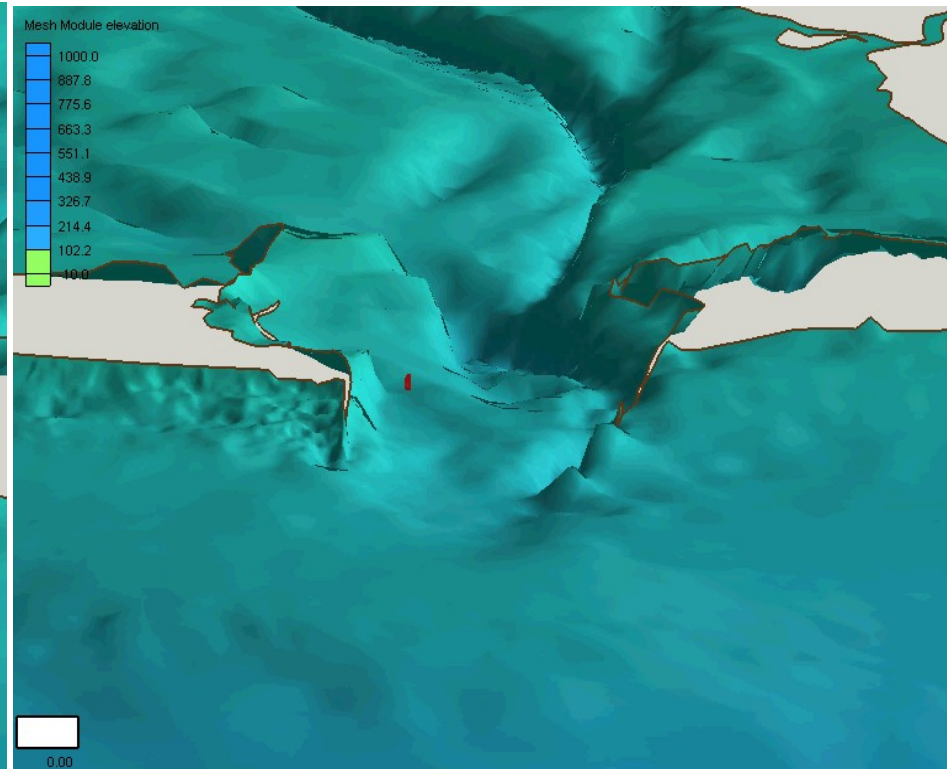
Particle Tracking Model (PTM)



Simulating dredged material placed near north jetty



Grays Harbor – view from SW



Grays Harbor – view from W

CIRP FY06 Work Units

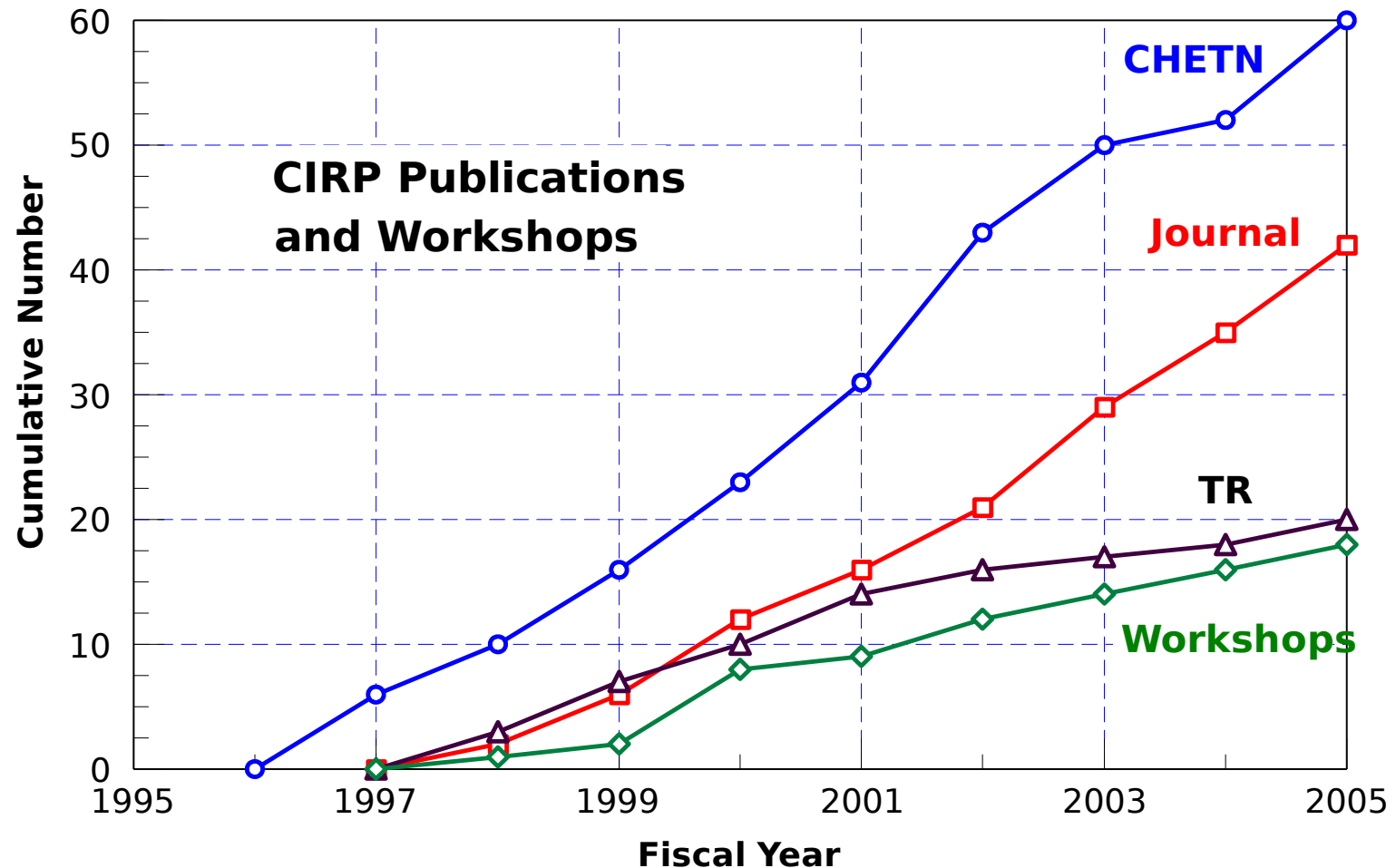


Work Unit	PI
Basic Inlet Processes	Lin
Inlet Bypassing & Nearshore Berms	Cialone
Inlet Geomorphic Evolution	Connell, Kraus
Validation of Predictive Technology	Rosati
Coastal Structures and Asset Management	Hughes, Melby
Advanced Navigation Modeling Simulation System	Demirbilek
Program Mgt/Tech Transfer, SMS	Kraus



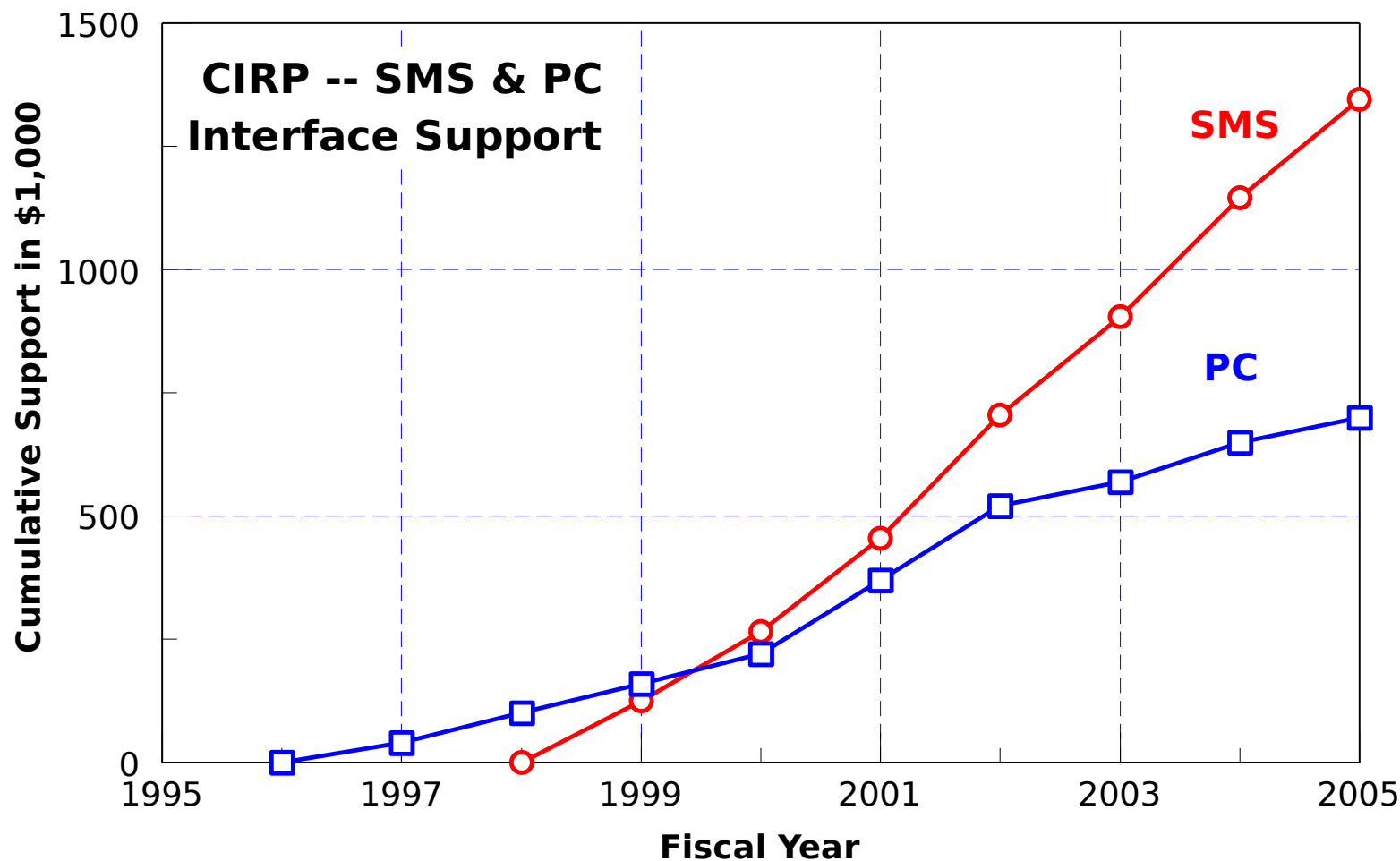
Quantitative Measures of Productivity

Publications & Workshops





SMS & PC Interface Support



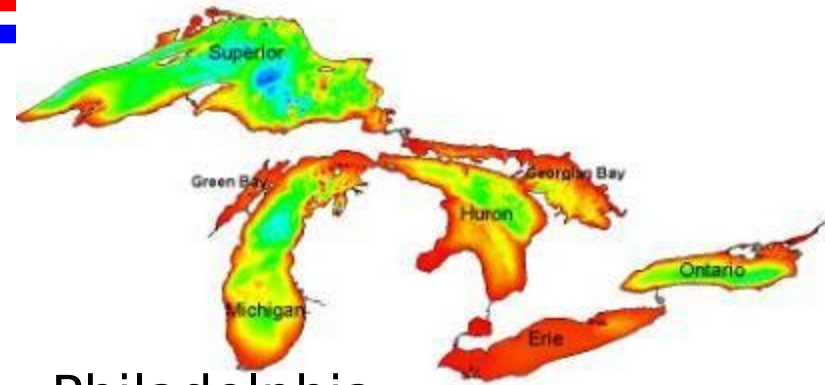
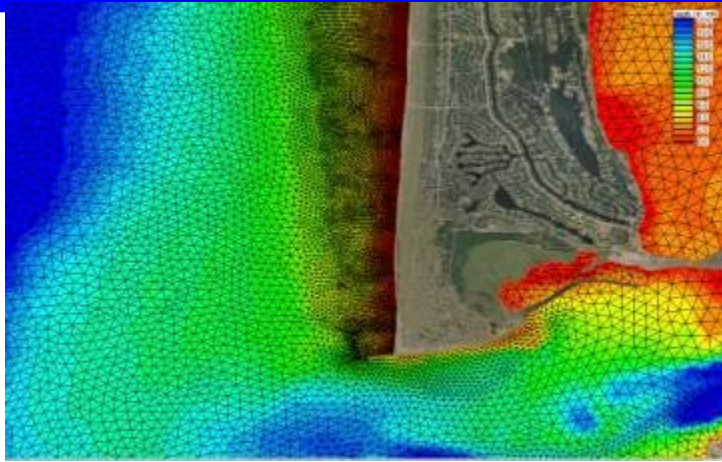


Progression of Major CIRP Technology-Transfer Workshops

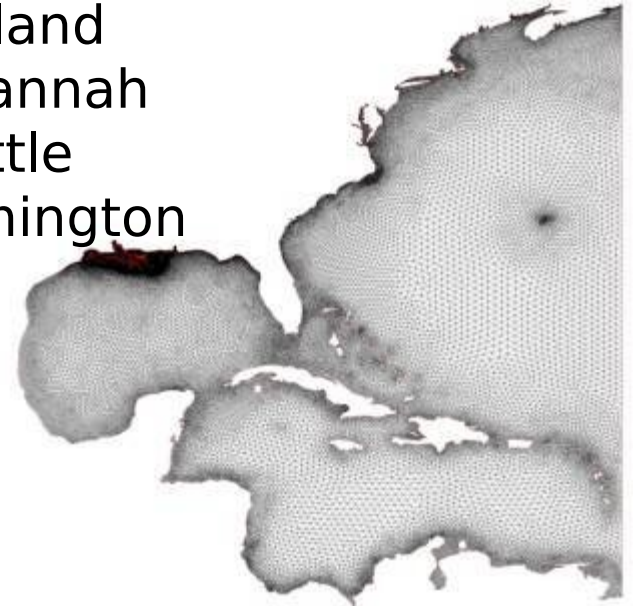
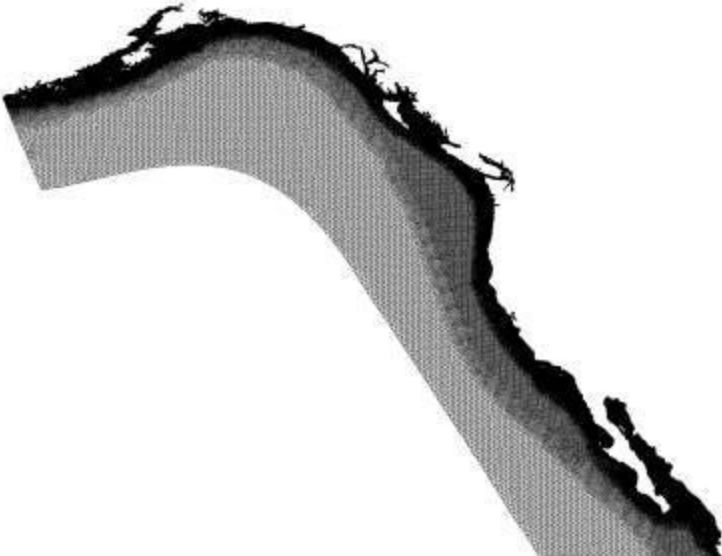


E & W Coasts Nov 1998	Avalon, NJ Redondo Beach, CA	Recent developments in CIRP: ADCIRC & STWAVE
Feb 2000 #1 - FSBPA	Melbourne, FL	Waves, tidal hydrodynamics, tidal inlet circulation
Feb 2001 #2 - FSBPA	Orlando, FL	ADCIRC, STWAVE, & ADCIRC/STWAVE linkages
Jan 2002 #3 - FSBPA	Biloxi, MS	GIS for coastal and navigation projects
Jul 2002	Vicksburg, MS	SMS Steering Module Workshop
Feb 2003 #4 - FSBPA	Ponte Vedra Beach, FL	M2D Hydro Steering Module and start of sediment transport/ morphology change
May 2003	Clearwater Beach, FL	CS03 Modeling Tidal Inlets
Feb 2004 #5 - FSBPA	Orlando, FL	Calculating sediment transport/morphology change (Watanabe)
Aug 2004	New York, NY	Hydrodynamic & Morphodynamic Steering Modules: Calculating sediment transport/morphology change (Lund-CIRP; Watanabe)
Feb 2005 #6 - FSBPA	Destin, FL	Modeling sediment transport and morphology change, channel infilling (Lund-CIRP; Watanabe)
Aug 2005	Baltimore, MD	Inlet Modeling System technology transfer workshop (SMS 9.0 new features, STWAVE, ADCIRC, IMS-M2D)
Jan-Feb 2006 #7 - FSBPA	Sarasota, FL	2D and 3D modeling of waves, circulation, sediment transport, and morphology change

Districts with IMS Training and/or Project Applications



Alaska
Baltimore
Buffalo
Charleston
Chicago
Detroit
Galveston
Hawaii
Jacksonville
Mobile
New Orleans
New York
Philadelphia
Portland
Savannah
Seattle
Wilmington





CIRP Spin-off & Collaboration



Spin-off to **RSM_SWWRP** Programs ERDC-Wide Thrust -- **SMS**

- Cascade
- SBAS-GIS

- Continue support
- Community Model

Spin-off to **Existing Models**

- Upgrade GENESIS (tidal current transport, T-head groins).
- Upgrade SBEACH -- overwash

Collaboration

- Particle Tracking Model (with **DOER**)
- Structure stability (**Section 227**)
- Improve STWAVE diffraction (**Nav S**)
 - Lab data sets
 - Funding for model enhancement



St. Mary's Entrance, FL/GA

CIRP- Accomplishments

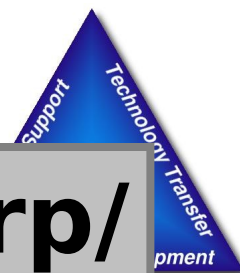


- Inlet Modeling System (IMS) – available via SMS.
- Sediment Budget Analysis System (SBAS).
- Inlet Reservoir Model for Sediment Bypassing.
- Particle Tracking Model (PTM) – jointly funded with DOER.
- Field data sets and laboratory data sets for validating technology.
- Breaching model – breaching near inlet jetties.
- Fundamental advances in understanding inlet stability, scour at jetties, coastal structure design.
- More than 20 technology-transfer workshops.
- Applications in support of difficult District
- CIRP website, online tools and guidance,



CIRP Website

<http://cirp.wes.army.mil/cirp/>



Website Objectives:

- Information about CIRP
- Technology Transfer
- Simple Online Tools
- Easy Site Navigation

Information: Publications:

- CIRP Research
- CHETNs
- Upcoming Events
- Technical Reports
- Past Presentations
- Journal Articles
- Photo Collections
- Conference Papers

